THE CONTROL
OF THE
WESTERN PINE BEETLE
(DENDROCTONUS BREVICOMIS)*

U. S. FOREST SERVICE
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Explanatory Note

In April, 1933, the Forest Service and Bureau of Entomology offices of Portland, Oregon jointly issued a forest insect handbook intended primarily for the use of Forest officers in Oregon and Washington. Among the insects discussed in this handbook is the western pine beetle (Dendroctonus brevicomis). Since this insect is at present the most important forest pest in Oregon and Washington and is of considerable interest in other portions of the West, there is constant call from private and public agencies regarding the habits and control of the western pine beetle. In addition, it is expected that control work in western pine beetle infestations in 1933 under the ECW program will necessitate a great deal of training work of new men for whom this information will be of help. For these reasons, the major portion of the discussions in the handbook on this insect is now mimeographed separately. Only such portions of the text of the handbook are included here as have a direct bearing on the organization of control work against the western pine beetle. Data on such special phases of the western pine beetle problem in ponderosa pine as the relationship between slash disposal and beetle outbreaks, the effect of fires on subsequent beetle activity, beetle attacks in reserve stands, winter-killing of the western pine beetle, etc., are included in the handbook but are not given here because of their lesser importance to those interested primarily in the control of the western pine beetle.

Because the material regarding the western pine beetle was taken from the handbook without the context and introductory statements, there is of necessity a lack of continuity and coherence in the discussions in the following pages. For the sake of ease of reference, the discussions have been divided into three sections. Section One deals primarily with a description of the western pine beetle and its work. Section Two consists of a description of the control work against this insect with special emphasis on the administrative features of such work. Section Three describes the procedure for establishing and measuring sample plots in ponderosa pine stands infested by the western pine beetle. Sample plots are frequently desirable as a basis for determining the need of control and for subsequently measuring the effectiveness of the control measures which are undertaken.

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*In order to obviate necessity of changing the page numbers on the stencils, the original page numbers in the handbook have been used.

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(Dendroctonus brevicomis Lec)

(Below)
Bark removed from infested ponderosa pine showing the typical winding egg galleries. Note the streaks of blue stain.

(Above) Inner surface of bark showing egg galleries packed with boring dust and (insert) adults, pupae and larvae, all natural size.

Section One

Description
of the
Western Pine Beetle and Its Work*

(Pages 1 - 7 inclusive)

*Extracts from the R-6 Forest Insect Handbook of April, 1933.

THE WESTERN PINE BEETLE
(Dendroctonus brevicomis Lec.)

One of the most serious enemies of ponderosa pine is a small insect known as the western pine beetle, (Dendroctonus brevicomis Lec.). Every year throughout the entire range of ponderosa pine from lower California to British Columbia thousands upon thousands of the largest and finest of these pines fall as victims to these tiny insects. The total destruction measured in board feet or in dollars is enormous. However, much of this is only the normal loss since in any one locality not more than one-third to one-half of one per cent of the stand is killed in any year. But frequently, in some locality particularly favorable to the beetles, they build up their numbers until hundreds of trees in every square mile are destroyed. And in one year, as much as ten per cent of the stand may be killed. Such a situation is called epidemic and calls for action on the part of the timber owner if he values his timber crop at all highly, and wishes to save as much as he can of it from destruction.

What It Is:

To the ordinary observer, the western pine beetle appears to be a small, brown to black, cylindrical, rather stout beetle with a body somewhat smaller than the ordinary house fly. The larvae of the beetle are small, white legless grubs about ¼ of an inch long with a small yellow head. They may be found by slicing half way through the bark of an infested ponderosa pine, and if the tree is at all heavily infested, will scatter out like so many grains of rice.

What It Does:

Boring through the bark, the beetles kill the trees by gnawing tunnels through the cambium layer, completely girdling them and thus cutting off the tree's sap. Besides attacking and killing standing green trees, it breeds to some extent in windfalls, broken or injured trees, and in the butts and cull logs left from logging operations or in the main trunk of trees felled in other types of cutting.

It confines its attack to the ponderosa pine, (and also Coulter pine in southern California) and to the main trunk of the attacked trees. Rarely does it go into tops less than six inches in diameter, or into the limbs.

How to Recognize Its Work:

Usually the first evidence that a tree has been attacked by these beetles is the sickly pale color of the needles. The faded appearance gradually changes to a yellow or sorrel and then to a bright red. In the first fading of a tree, the needles die from the center of the needle clusters outward and usually from the top of the tree downward. During the normal process of shedding the old needles a tree sometimes has so many dying needles that it resembles an infested tree although it may be perfectly healthy. However, it will be noted that on these healthy

trees, the center of the needle clusters at the tip of the branches are green, while an infested tree is characterized by the dead tips with possibly green needles further back on the branches.

On closer examination of the infested tree, small circular holes about 1/16 of an inch in diameter, will be noticed in the bark, usually in the crevices. A very small amount of sawdust will be found in some cases, and occasionally pitch tubes cover the holes through which the beetles forced their entry into the tree. Upon chopping into the suspected tree so as to expose the sap wood and inner surface of the bark, the winding egg-galleries will be found in the inner bark. These egg-galleries, which are slightly larger in diameter than the beetle, are filled with sawdust and cross and recross each other in such a manner as to form a network of irregular lines. This peculiar type of egg-gallery is characteristic of the species and can be said to be the hieroglyphic or signature of the western pine beetle.

If the tree has just recently been attacked, the bark will still be tight on the sapwood, not discolored, and the fresh dark-brown beetles will be found in the galleries with small white eggs about the size of a pin point deposited in little niches on the walls of the gallery. Sometime after the attack, the inner bark withers, becomes discolored and brown and loosens from the tree. At this stage the parent beetles will be found at the end of the egg-galleries where they finally die.

After the eggs have hatched, the small worms burrow for a short distance in the outer bark where they reach maturity, transform to the pupae or resting stage and then change to new beetles. These new beetles are at first very light in color but gradually they darken as their shell hardens. Soon they are ready to emerge and to attack other trees.

On leaving the tree each beetle burrows out for himself leaving a neat round exit hole in the bark, so that the tree from which many beetles have escaped looks as though it had been peppered with bird shot. Trees in this condition should never be felled or burned as the destructive pine beetles have already escaped and only the predatory insects which prey upon them and leave the tree after the emergence of the beetles, will be destroyed.

Its Seasonal Development:

The western pine beetles develop and work so rapidly that trees which are attacked in the early summer are killed and abandoned before fall and their progeny are at work on other trees which are killed before winter. It is in these later attacked trees that the beetles spend the winter in a semi-dormant condition.

After emergence from the dead trees the new beetles enter a period of flight, after which they concentrate upon certain trees to which they are attracted and start their attacks. The first attacks on a healthy tree usually start near the top and the beetles keep coming in numbers for a period of several days or a week until the natural resistance of the sap flow of the tree has been overcome and the girdling of the tree by the egg-galleries has been completed. A successful attack requires about 24 parent adults to a square foot of bark or about 7,000 beetles to a 24 inch 5-log tree.

Within a week or two after the attack, the tree dies. The parents mine their egg-galleries and deposit eggs which hatch in about 7 days. The grubs feed upon the sap of the dead tree, complete their growth, change to pupae, then to new adults and finally the new broods leave the tree. These new broods emerge from the summer-killed trees during August, September, and October. From actual counts, it has been found that enough new beetles are hatched from a single infested tree to kill eleven other trees provided all beetles made successful attacks. However, many of the beetles which emerge are lost during the flight period, are killed by predators, or are drowned out by the sap flow in trees which they do not attack in sufficient numbers to overcome. This mortality of the beetles accounts for the occasional natural control of epidemics and the consequent failure of the beetles to increase for a period of years.

The beetles which emerge from so-called "summer trees" attack and kill new trees during September, October, and November. After the attack, eggs are laid and the development of the brood continues until it is stopped by the cold winter weather. The insects then pass the winter in all stages of development, namely as parent adults, eggs, larvae and occasionally pupae and new adults. They renew their activity and development again in the spring with the advent of the first warm weather.

It is during the late fall, winter and early spring period when the beetles and grubs are still in the bark of the trees that the greatest good can be accomplished through control measures.

How They are Regulated Under Natural Conditions:

Under natural conditions the western pine beetle has many enemies such as parasitic and predaceous insects, mites, bacterial and fungoid diseases, and birds.

One of the most important enemies of the beetles are the woodpeckers. They will be seen hammering away on the "bug trees" during the fall, winter and spring and succeed in devouring great quantities of the grubs. Sometimes a heavily infested tree is almost stripped of bark by the wood peckers in their search for grubs.

There are also two species of beetles which devour great numbers of the adult pine beetle before they can bore into the bark to protect themselves. One of these, a Clerid, (Thanasimus nigriventris) is a grey beetle about three-eighths of an inch long. They may be seen on warm days running actively over the bark of trees which are being attacked by the pine beetles. These predators are attracted to the tree by the attacks of the first beetles, and they seem to have the habit of lying in wait for the beetles as they come to the tree. Another common factor is an Ostomid, a bright metallic green or bluish green and somewhat flattened beet e equipped with strong pinchers. The larvae of both the Clerid and Ostomid live under the bark and feed on the immature stages of the pine beetle.

Through the operation of what is known as the law of the balance in nature, when the western pine beetle increases and becomes epidemic, their enemies wax fat and prosperous due to increased food supply, until they become so abundant that they outweigh the pine beetles. The pine beetles then are reduced until the predators die off for lack of food, and then the cycle is repeated. This, together with many other factors such as unfavorable climatic conditions helps to explain the periodicity of the pine beetle epidemics.

In the long run the beetles do not completely destroy the forests, for it is practically certain, that they have always been present in the forest, but they can so seriously reduce the mature timber crop that it may take several decades for the forest to regain the loss in volume.

How the Beetles can be Artificially Controlled:

In order to prevent the great destruction of commercial timber, by these beetles, and more quickly restore the balance in nature, the Bureau of Entomology has devised certain methods of control.

The two principal methods which have been used to destroy the infesting broods are the burning and the sun-curing methods. These methods are best applied in the late fall, winter or early spring during the period of beetle activity.

The Burning Method: The burning method consists of felling the infested trees, peeling the bark from the top half of the log well down on the sides, and as far along the log as it is infested, piling this bark alongside of the log and then burning it. Trees should be felled, when possible, away from standing trees or reproduction. To make a clean job, the limbs are removed, the top lopped off and brought back over the log, the limbs piled on top and all of this debris burned. Late in the spring season when the forest becomes dry it is safer to pile the brush away from the tree and make a fire line around the log. By varying the amount of material left on and around the log, and the width of the fire line, burning can be carried out at any time of the year and during the driest weather with perfect safety. When the bark is wet with snow or rain it is necessary to cut pitch and other dry material to lay along the log in order to get heat enough to insure a good burn.

Small trees, if in groups, are usually cut, bucked up and piled together and the entire pile burned. This is much cheaper than attempting to peel them. In this case, the fire is usually hot enough to consume all of the limbs and main stem. On the larger trees only the bark is burned and the peeled log is simply scorched, and can be used later for lumber provided it is removed from the forest within two years. Trees which have been peeled and scorched do not deteriorate as rapidly as those which are left standing with the bark attached. So that, while control work appears to be a very destructive operation, nature's own processes are even more so.

The Sun Curing Method: A few years ago the discovery was made, that if bark infested with the western pine beetle was peeled from the trees and laid so as to receive the direct rays of the sun, the beetles would be killed by the excessive temperatures produced.

This method, therefore, gained favor as a summer method of control when the cost of necessary fire precautions became excessive.

In using this method, the attempt is made to fell the trees so that most of the infested trunk is off of the ground. The tree is then limbed and the brush piled at least 10 feet away from the tree so as to give a space in which to spread the bark. All of the infested bark is then peeled and spread on the open ground, (either side up) where it will get the direct rays of the sun for at least two hours during the middle of the day. In case the tree has not been bedded so that all of the underside may be reached in peeling, the log should be rolled so that the bark of the under side may be removed.

However, in the practical application of this method, difficulties were encountered. Slope, exposure, denseness of forest cover, brush, cloudy weather and many other factors made the effectiveness of the method an uncertain quantity, so that, it is no longer used on any extensive scale.

Trap Trees: Trap trees as a means of localizing infestation and simplifying control have often been advocated. After extensive tests on the San Joaquin project in California, the conclusion has been reached, that "trap trees" fail to trap infestation in sufficient quantity to protect the surrounding forest. Their use, therefore, as a means of control is not advocated, unless the timber can be utilized.

Control Through Logging: Although control through logging has only been used to a very limited extent, it offers the advantage of helping to pay the cost of control through the sale of the salvaged timber.

To destroy the beetles, the infested trees should be either removed to a mill several miles from the forest or the logs placed in the mill pond and left for more than six weeks, or the logs cut into lumber and the slabs burned before the broods emerge.

This method could be applied in many different ways, such as in combination with the sale of a limited amount of green mature timber, with cuttings carried on as purely a control measure during the summer, closing at the beginning of beetle activity. It could only be profitably applied on a unit reasonably close to a saw mill, or whether the topography did not preclude the use of a portable mill.

It has been noted that cutting operations are very attractive to the beetles, so that where the infestation is removed with the logs for a season or two a greater reduction of infestation in the general vicinity is brought about than by any other control method.

When Should Artificial Control Be Undertaken?

The results of recent experiments indicate that it does not pay to attempt to control or reduce normal infestation. The balance in Nature is adjusted to provide for a certain amount of insect loss each year and attempts to avoid this loss may so upset the natural balance as to precipitate an epidemic.

If, however, a careful examination indicates that the beetles are rapidly advancing to or have reached epidemic proportions, then artificial control should be resorted to provided:

1. That the timber values at stake, either from the commercial, recreational or aesthetic standpoint, warrant the cost of control measures.

2. That the cooperation can be secured, of all owners in the affected territory so that an entire basin or natural topographic unit can be included in the control program.

3. And that control measures can be applied on a scale extensive and thorough enough to insure success, which will require:

(a) That on small, well-isolated areas the entire infestation be treated in one season; or

(b) That on larger units with partial isolation, one season's treatment will be followed by maintenance control or will be logged within three or four years; or

(c) That on large commercial holdings, isolated or not, control work can be accomplished through selective logging and salvage at a very low cost or at a small profit.

To be effective, the control work should remove as near one hundred per cent of the over-wintering infestation within the treated area as is physically possible, and should extend to the natural boundaries of the ponderosa pine type or to one mile or more beyond the edges of the area under protection. Western pine beetle broods from contiguous infested timber can be expected to work back into the treated area at the rate of about one-half mile to each generation or about one mile per year in the central part of its range.

What are the Chances of Success?

So far wherever artificial control measures have been applied to epidemic infestations they have been successful in reducing the infestation and have helped to restore the balance in nature. Where timber values have been high, the amount of timber saved has more than offset the cost of the work.

On the whole, artificial control work against the western pine beetle can be looked upon as a profitable form of timber insurance.

Other Similar Insects in Ponderosa Pine.

There are several other insects which are found in ponderosa pine which are often confused with the western pine beetle. Some of the more common ones are:

The Mountain Pine Beetle (Dendroctonus monticolae Hopk.) is a larger beetle than the western pine beetle, is black in color and is found not only in ponderosa pine but in sugar pine, lodgepole pine, white pine, etc. Its egg galleries run straight up and down the tree and the larval galleries run at right angles to the egg-galleries. The larval galleries are much more conspicuous than the larval galleries of the western pine beetle. The pupae form cells in the inner bark and usually the larvae, pupae, or new adults can be seen by simply removing the bark without slicing it. In ponderosa pine this beetle will usually be found in the smaller trees, less than 20 inches in diameter. It is a serious enemy of pines and should be regarded as a primary insect.

The Turpentine Beetle (Dendroctonus valens Lec.) is a large red beetle of the same general shape as the western pine beetle and is found usually in the base of the infested trees and in stumps. The larvae feed in masses between the bark and wood and the pitch tubes near the base of the tree are always conspicuous.

The Engraver Beetles (Ips confusus and Ips oregoni) are small, brown cylindrical beetles without visible hairs and are easily distinguished by their peculiar rear end which appears as though a chunk had been bitten out of the top side. They can also be distinguished from the western pine beetle by the character of their egg-galleries which are free from sawdust and with conspicuous egg niches. The beetles are often encountered in the tops of trees killed by the western pine beetle, in limbs and down logs, and in pole stands of young trees.

The Large Engraver Beetle (Ips emarginatus) is about the size of the mountain pine beetle but can be distinguished from it by the elytral notch on its rear end. Its work can also be distinguished from the western pine beetle as the egg-galleries are clear of sawdust while the western pine beetle galleries are packed with this material. This species is occasionally found in ponderosa pine trees infested by the western pine beetle.

The Hylurgops Beetle (Hylurgops subcostulatus) is a beetle very similar in appearance to the western pine beetle except that it is slightly longer, of a duller color and of a rougher texture. It is usually found under the bark of sour-sap trees. The beetle makes no definite egg-galleries, a characteristic which distinguishes its work from that of the western pine beetle.

Section Two

Control of the Western Pine Beetle*

(Pages 47-83 inclusive)

Note: - The terms endemic, normal and epidemic infestations are frequently used in the text of this section and no clear definition of them has been given. The terms endemic and normal are used interchangeably to describe a western pine beetle infestation in ponderosa pine which shows no signs of aggressiveness and no tendency to increase. Such infestations rarely kill more than one tree to each 15 to 30 acres annually, or from 20 to 40 trees per section. This loss approximates one-third to one-half of one per cent of the ponderosa pine volume. This beetle-killing is confined largely to over-mature, decadent trees and occurs in the form of scattered single trees and not as groups of trees. Quiescent infestations of this character are to be found in nearly all stands of ponderosa pine - there are no large bodies of ponderosa pine in Oregon and Washington without some western pine beetle (D. brevicomis) infestation. Infestations may remain in a normal status for many years. Except in an experimental way, no control work in normal infestations has been undertaken in Region Six.

Epidemic infestations are those in which the beetle losses are in excess of those described for normal infestations. Among the first evidences of the change of an infestation from the normal to the epidemic status, are the occurrence of groups of infested trees in place of the scattered single trees which had been killed heretofore, and the ability of the beetles to kill the thriftier trees. This change from the normal infestation to the epidemic of destructive severity may take place so gradually over a period of two or more years that it is easily overlooked in the earlier stages by those not familiar with the habits of the western pine beetle. In other cases, as after fires or windfalls, the change from a normal infestation to a severe epidemic may occur within a year. There is a wide variation in the severity of the beetle losses that are caused by so-called epidemic infestations. The annual epidemic losses vary from 50 to 1000 trees per section. This is equivalent to one-half to ten per cent of the ponderosa pine volume of the stand. In the past, all regular control work in Oregon has been directed against epidemic infestations or those which clearly give evidence of becoming epidemic.

*Extracts from the R-6 Forest Insect Handbook of April, 1933.

CONTROL OF THE WESTERN PINE BEETLE

1. Entomological Considerations

Without doubt, the western pine beetle (Dendroctonus brevicomis) is the most important forest insect in the North Pacific Region. A detailed description of its habits and its destructiveness has been given in the early pages of this manual (see page 1). This pest confines its work to ponderosa pine and is, therefore, of special interest to Forest officers whose responsibility involves the protection of this tree species.

The western pine beetle is a difficult insect to control. To be successful, a control campaign involves more than a mere effort to kill a lot of bugs by cutting, peeling, and burning the infested trees in a beetle-ridden forest. In spite of the fact that barkbeetle control work has been in progress in Oregon and Washington since 1910, there is much about the whole problem which is still imperfectly understood. For this reason, the Bureau of Entomology continues to give the barkbeetle problem a major position in its investigative work on forest insects.

The difficulties which beset successful control work, the conditions under which success can and can not be reasonably expected, and the results of past control projects, were briefly discussed by four forest entomologists of the Bureau of Entomology in the November, 1931, issue of the Journal of Forestry, in an article entitled "Control work against barkbeetles in western forests and an appraisal of its results." This article so clearly summarizes the situation that those portions of it which are applicable to the western pine beetle situation in the North Pacific Region will be quoted. Some of the sections of the article which will be quoted, were written to apply to all species of Dendroctonus and not particularly to the western pine beetle. Nevertheless, even this general material assists in a better understanding of the western pine beetle problem.

General features of the control problem

A few statements regarding the general control problem are quoted from the article as follows:

"Ever since forest protection entered into the program of federal and private owners of our western forest areas, the control of these insects that kill timber by mining the cambium of living trees has been a problem of increasing importance. In the efforts to combat this destructive agency, direct measures of artificial control developed by entomologists have, during the past few decades, been applied on a fairly large scale against the more important Dendroctonus beetles, and to a very small extent against species of bark engravers (Ips spp.) and flatheaded borers (Buprestidae).

"Such methods were untried to begin with, and their effectiveness could be determined only by actual test in the field. The owner of threatened timber was obliged to make his decision between these two courses of action; either to let Nature take its course and await developments, hoping that natural factors would check the insects; or to spend money on expensive direct measures of control, without positive assurance that the results would be profitable or lasting. In spite of the uncertainty as to what might be accomplished by employing the methods and plans recommended by entomologists, control campaigns of a fairly comprehensive nature have been undertaken on both federal and private timberlands.

"With this great amount of work as a background, and with the experience that has been acquired, it seems desirable to take stock of the results obtained and to decide just how this phase of forest protection has paid off on the investment. Without regard to preliminary theories and expectations as to results, what projects have accomplished an actual saving of timber? Under what conditions has control work succeeded and under what conditions has it failed? Continuation of this activity on the scale now being advocated in national forests, parks, and other holdings, should at least be guided by the answers to these questions, based upon an unbiased analysis of results of past work.

"Control methods necessarily must be based upon information regarding the seasonal history and habits of the insects, and also, until thoroughly tried out in practice, upon certain conceptions and theories. In the employment of proposed methods, it was at first taken for granted that the killing of beetles saved trees. This theory depended largely on the early assumption that when a newly-developed brood of beetles emerges from an infested tree, the beetles attack and kill another tree in the vicinity, so that each succeeding generation kills a fairly regular quota of trees. Therefore, destroying the broods in one infested tree before they emerge saves at least one living tree from attack by the next generation. This conception, if it were the whole truth, would greatly simplify the problem of estimating costs and appraising benefits derived from control work. Obviously, on this basis, the volume of timber saved would be in direct proportion to the amount of timber treated. However, it was soon realized that so simple an idea of the problem failed to take into account the complex biotic factors which control the abundance of insect populations and govern the rise and fall of bark-beetle epidemics. These even now, after many years' experience in control and investigation, are very little understood."

Difficulty of appraising results of past control work.

Why it is difficult to draw any hard and fast rules from the experience of past control work is shown by the writers in further quotations from the article. Some of the difficulties of such an analysis are stated as follows:

"1. Lack of accurate data obtained after the completion of the work from the area treated. Some projects have been closely studied by the Bureau of Entomology, but on many others no attempt was made to measure the actual volume of reinfestation that developed after control work was completed.

"2. Lack of suitable check areas by which a treated area could be compared with an untreated one. To a great extent this lack of checks is due to natural conditions which can not be remedied. No two areas are even identical, and seldom even similar in all their aspects, and it is therefore difficult to reach a conclusion on the results of control work by comparison with check areas.

"3. Obscurity of the natural factors influencing the course of the infestation before, during, and after the period of control work. These factors, such as the effects of climatic influences and predators and the distances which beetles fly in reinfesting a control area, may completely outweigh and make it difficult to evaluate the influence of artificial control.

"4. Wide variation in objectives, in the control operations that have been undertaken, and in the values, aesthetic or commercial, to be protected. On recreational areas like those in southern California, control work can be considered successful if only a few trees are saved at high cost. In the commercial timber stands of the Northwest, on the other hand, it is frequently the case that a control operation, to be successful, must cause the permanent saving for the sawmill of a quantity of potential lumber worth more than the amount of money spent in killing the beetles. Therefore considerations not purely entomological often enter into the appraisal of results on certain projects.

"Another phase of the results from control which has received very little consideration up to the present time, has to do with the indirect benefits of the forest. These are seldom tangible and are very difficult to estimate. Perhaps the most important is the reduction of fire hazard within the control area, through the removal of trees which would otherwise stand as snags to start lightning fires and to spread burning embers when fires occur. Forests which have been swept by bark-beetle outbreaks, and in which thousands of dead trees have been left among the surviving live ones, become tremendous fire risks and remain so for years. Control methods which require the felling of infested trees serve to remove many of these dangerous snags from the stand. Projects, therefore, which do not show an actual profit from the viewpoint of the amount of timber saved from beetle attack may, in the long run, pay through reduction of the fire hazard.

"Some forest-protective organizations have maintained yearlong employment for their summer fire-protection force by carrying on insect-control work during the winter period, and consider this good practice, even though the reduction of infestation is not outstanding.

"From the considerations just enumerated, it is obvious that the entire problem involved in the formulation of a control policy is very complicated and can not be settled by merely laying down a few hard-and-fast rules as to when and where and under what conditions control work is to be recommended. Local conditions and values, and quite often other considerations that are not entomological, must largely determine the plans and strategy for each specific project; and these factors should be taken into account in determining the success or failure of each undertaking.

"With all these considerations in mind, it is obvious that any broad conclusions as to the results of past projects are subject to many reservations. However, at least one outstanding conclusion applies to the entire matter, and may be stated as follows: Each species of bark beetle presents its own special problem and must be dealt with differently from other species as to control methods and strategy and even the same species may present problems which differ in different regions. The management of control operations must therefore vary according to local conditions within the area to be protected."

Characteristics of outbreaks of the western pine beetle.

The article summarizes some of the characteristics of infestations of the western pine beetle as follows:

"The western pine beetle is by far the most destructive enemy of ponderosa pine over a great part of its range through British Columbia, Montana, Idaho, Washington, Oregon, and California. Everywhere throughout the ponderosa pine forests of this area it kills a few trees each year. It is in California and southern Oregon, however, that its depredations are the most serious, and the losses here frequently run into hundreds of millions of board feet annually.

"Under endemic conditions, this bark beetle shows a decided preference for the slower-growing trees, and confines its attacks to single trees and small groups of seldom more than 4 or 5 trees in the overmature stands on the poorer sites. But when outbreaks become epidemic, it shows less discrimination. The groups increase until they may include from 50 to 100 trees each, and extend into the better sites and include faster growing stock. Under any condition, the infested trees and groups are distributed more or less evenly over large areas.

"Observations on the same area over a period of years indicate that in some cases losses are rather closely correlated with climatic conditions. Periods of drought with a deficiency of soil moisture result in a building up of epidemics. With a return to conditions of normal moisture, tree growth is accelerated and the losses decrease. Sometimes low winter temperatures cause a high mortality in the broods and bring about sudden declines in the losses."

Results of past control work and conditions under which future work is recommended.

An appraisal of the results of past control work and the conditions under which future work is recommended, are described in the following quotations from the article:

"Admittedly the success of all these projects for western pine beetle control has not been spectacular or outstanding. In many cases the work has shown tangible results, but often these results were not substantial enough to show a profit. Some projects were apparently failures. The data to prove positively either success or failure of certain projects are often inadequate. Indirect benefits of control work, such as the reduction of fire hazard, are usually too intangible

to be appraised. With the data at hand any broad conclusions, therefore, must be based upon convictions of entomologists and owners who have had long experience in this work, rather than upon overwhelming weight of evidence. The predilection of the western pine beetle for slow-growing trees and its apparently quick response to climatic influences must also be taken into consideration. With these limitations in mind, it is believed that the following conclusions are considered reasonable by all who have followed and closely analyzed these projects.

1. One season of thorough control work results in a reduction of western pine beetle losses on the treated areas as compared with similar untreated areas.

2. The benefits have been greatest when the natural tendency of the infestation was upward.

3. Under a declining infestation, there was only a small difference in favor of the treated over the untreated areas.

4. The benefits from control work have been temporary, lasting only one or two seasons, and a return to conditions similar to those on untreated areas can be expected unless work is continued on the same area year after year.

"In the face of these results, under what conditions is direct control work to be recommended? Considering both economic and entomological factors, control of the western pine beetle is believed practicable under the following conditions:

"1. In parks and on recreational areas with high values, where trees are objectionable and should be removed for aesthetic considerations or for those of forest sanitation. Under these conditions, control work need not necessarily pay its way on the basis of stumpage values saved from further beetle attack.

"2. On small, well-isolated areas, where the timber is of high value and where the entire infestation can be treated in one season.

"3. On large areas, preferably with partial isolation, where the entire infested area can be treated and where it is to be logged within three or four years.

"4. In commercial stands, whether isolated or not, where control work can be supplemented by logging and salvaged at a low cost or a small profit. Such work may be combined with selective logging to remove susceptible trees and produce better growth conditions, in order to give permanent protection for long periods."

2. Methods of Control

Peeling and burning

This method of control is the one most commonly used in handling western pine beetle infestations. It involves the cutting of the infested trees and peeling and burning the infested bark.

The infested trees containing the live broods of beetles are located by their characteristic color or boring dust in the crevices of the bark. They are then felled and the bark is peeled from the top half of the fallen trunk and piled along the sides. If a group of trees is infested they are felled together and only the upper sides of the exposed trunks on the top and sides of the pile are peeled. The limbs are trimmed and the top is cut off and all piled back over the trunks. If the forest floor is at all dry, a fire line is constructed by scraping away all of the litter and duff down to the mineral soil for a width of about three feet and completely encircling the tree, and the entire pile is then burned. Ordinarily the fire is not hot enough to burn the logs and, if at all accessible, they can be used for lumber later.

The trees should be felled either up or down hill and away from reproduction and heavy patches of brush and never across the slope of a hill, if it can be avoided, since a broad flame is much more difficult to handle than a narrow one.

The fire should be regulated to give enough heat to consume the infested bark, but should not be so big as to make it difficult to control. In wet weather pitch will have to be supplied to sufficiently burn the bark, while in dry weather all of the tops, limbs and even needles will have to be thrown outside of the fire line in order to keep the fire from becoming too large. In wet weather, burn with the wind and uphill in order to create enough draft to consume the bark; in dry weather, never do so, but burn downhill and against the wind so as to be able to control the fire. Burning, if done by experienced men, can be handled without injury to the forest.

Submerging the infested logs

This method was first advocated by Dr. Hopkins in the control of the bark-beetles, and was expected to be of particular value where the infested trees could be cut and placed in a mill pond.

Recent experiments have shown that submergence requires about six weeks to kill the bark-beetles. If logs are submerged for less time than this, the beetle's development is simply retarded.

So far this method has not been used in the control of forest insects except in an experimental way. It offers possibilities, however, especially in connection with a selective logging program, or in the treatment of infested trees around the lake shores of recreational areas.

Use of trap trees

Since many of the injurious bark-beetles are attracted to felled trees, the idea of felling some of the injured, weakened, or noncommercial trees in accessible locations for beetle bait and then destroying them after the beetles have entered the bark of such trees has been advocated. This method has been used in Europe for many years with apparently beneficial results.

Experience with this method has shown that while the felled trap trees will attract many species of bark and wood-boring insects, they will not always attract the beetles which are the most destructive to the healthy trees. Often the destructive beetles will be attracted to the vicinity of the felled trap trees but instead of attacking the trap will attack and kill healthy living trees near by. Moreover, the trap trees have always failed to absorb any large proportion of the beetles on an area and hence can be considered of limited value as a means of control.

Removing the infested logs from the woods

This method was first advocated by Hopkins in the control of the Dendroctonus beetles. He recommended that the infested logs be removed from 20 to 50 miles from the forest so that the beetles emerging from them would find no trees to attack.

Often this method has been used unconsciously by logging operators and sometimes explains the absence of insect killing around some logging operations. Infested trees have been cut and the logs sent to a mill many miles away; or if the mill is close at hand the logs have been placed in a pond or the slabs burned. This process, together with the removal of beetles in felled green logs which they have freshly attacked, has acted as a control adjacent to these logging operations.

No actual control project has been conducted along these lines, but the method is quite workable and satisfactory in connection with any selective logging operation.

3. Desirability, Organization and Cost of Control Work

Whenever the western pine beetle has become aggressive in the forest and responsible for the death of large numbers of trees, the application of direct methods of control is advisable, provided the value of the timber which can be saved through the work will justify the expense. To apply this general rule requires that certain data be obtained and certain decisions reached.

First, a survey should be made of the infested area and information secured as to the cause of the death of the trees. If the trees are dying primarily because of drought, fire injury or disease, there is obviously little use to control the insects when they are only a secondary cause of the death of the trees.

Second, if the western pine beetle is found to be the primary cause, is it aggressively epidemic or only carrying on its normal activities? In this connection, it has been found that control measures usually have little effect in reducing the normal loss within the forest, unless the measures are very intensively applied.

Third, what area is affected? How many trees are being killed? And will the value of the timber saved justify the expense of control? In general, it may be said that the stumpage value of the timber per M b. m. should be equal to or greater than the cost of treating a similar unit. Under present conditions the cost of treating will average $2.50 to $3.50 per M board feet.

And lastly, will it be possible to secure the cooperation of all the owners within a given area, so that the clean-up can cover all of the contiguous infested territory? Small tracts can not be successfully cleaned up if neighboring tracts are left untreated.

The control of the infestation having been decided upon, the next step is the organization of the owners and crews to carry on the work.

For best results, the actual work of felling and treating the trees should be turned over to a well-organized crew of of workmen under the direction of a man familiar with control methods. Such a crew usually consists of a camp of from ten to thirty men, and includes a foreman, cook, saw filer, spotters, and laborers.

Trained spotters mark the trees to be cut and treated. They usually cover the area by running strips, five chains in width, back and forth across the area; locate the infested trees by their distinguishing characteristics; blaze and tag the trees so that they can be easily found by the treating crews; and plot them on map sheets to be used by the treaters in finding the trees.

The laborers in the camp are usually divided into treating crews of from two to three men. Each crew is assigned to clean up a given area and under the supervision of the camp foreman do the actual work of felling, burning, or peeling.

In western pine beetle infestations, there are so many other factors which are primarily responsible for the death of the trees, that sometimes the reduction of the beetles on the area has not resulted in much improvement in the situation, and trees continue to die from one cause or another even without the assistance of the bark-beetles. For this reason, control should be undertaken only after it has been definitely established that the western pine beetle is the primary cause of the trouble.

On the whole the artificial control work which has been carried on against the western pine beetle has given satisfactory results in reducing aggressive infestions and in saving timber from beetle destruction. Where the timber values have been sufficiently high, the amount of timber saved has more than offset the cost of the work.

When timber in private ownership is a part of the area to be covered by control operations, full participation of the owners of such land must be arranged before detailed plans are made for the Forest Service portion of the project. In Oregon, the so-called "pine beetle law" is invoked by timber owners who anticipate difficulty in securing cooperation of the owners of neighboring private timber. This law is stated in the next few pages.

4. The Oregon Pine Beetle Law

When the owners or representatives of 60 per cent or more of the private ownership in an infested area in Oregon are ready and anxious to cooperate with the Forest Service or any other agency in a complete cleanup of an infested body of timber, the so-called "Oregon Pine Beetle" can be invoked to compel the cooperation of such owners whose help can not be secured voluntarily. Inasmuch as Forest officers will have occasion to refer to the provisions of this law from time to time, it is stated in full as it appears in Chapter III of the Oregon Forest Laws, 1931.

"Public nuisance.

Pine beetles and other insect pests and infestations harmful, detrimental and injurious to timber and forest growths and to timber infested thereby are hereby declared to be a public nuisance.

Landowner - Eradication of pests.

Every owner of timber or timberlands shall control, destroy and eradicate such insect pests, or provide for the same to be done on lands owned by him or under his control, but in case of his failure or neglect so to do, such work may be performed as provided for in this act.

Infested area - Notice to state forester - Investigation - Notice to abate nuisance.

When any owner, or owners of timber or timbered lands shall find the same infested with pine beetles or other insect pests, or shall find timberlands adjacent thereto so infested, he or they shall immediately notify the state forester thereof, whereupon it shall be the duty of the state forester at once to investigate such condition and if in his opinion the infestation is of such a character as to be injurious to forest growths and a menace to timber or timbered lands, the state forester, with the approval of the state board of forestry, shall declare a district or zone of infestation, and declare and fix boundaries thereof so as to definitely describe and identify such district. Thereafter and upon written application of the owners of 60 per cent or more of the timber or timbered lands within said infestation (infested) district that the provisions of this act be enforced and that said nuisance be abated and that the said insect pests be eradicated and destroyed, the state forester shall at once notify all owners of timber and timberlands within the said district to proceed under the provisions of this act without delay to destroy and eradicate the said pests as provided herein. The said notice may be made by personal service, or by mail, addressed to the last known place of address of such owner, sealed, plainly addressed, with the requisite amount of postage stamps thereon, and deposited in the United States post office. Such service may be made on an agent of the owner, or upon any person of legal age in possession of or residing upon said lands.

Owner failing to abate nuisance - Duty of state forester.

If the owner or owners referred to in the last preceding section fail, refuse or neglect to comply with the requirements of said notice for a period of 30 days after the date thereof, it shall be the duty of the state forester, or the person or persons authorized and directed by him, to go upon said lands, using such assistance and help as he may deem necessary, and to cause such insect pests to be eradicated and destroyed in such manner as shall be approved by the state board of forestry.

Expense of eradication by state - Entry on lien docket - Enforcement of lien.

Upon the completion of said work so directed and authorized, the state forester shall make and file with the county clerk of the county wherein the said infestation (infested) district or zone is situated, a verified statement of the expenses necessarily incurred in performing the work of eradicating said pests. Upon the filing of said statement the county clerk shall cause the same to be entered upon a lien docket prepared and kept for that purpose. Said expense account when so filed and docketed shall constitute a first lien upon the timberlands upon which such work was performed, second only to the lien for taxes. If said charges and expenses shall not be paid and fully discharged within ninety days from the docketing thereof, it shall be the duty of the district attorney of said county to bring suit or action in the name of the state board of forestry for the foreclosure of the said lien, and the lands and timber included in said lien shall be sold in the manner provided by law under execution, and the moneys arising therefrom shall be applied in payment of the costs and disbursements of said suit or action and in the payment and discharge of said lien. All moneys so recovered shall be paid over to and become a part of the funds of the state board of forestry and applied in reimbursing said board for the expenses incurred in eradicating said pests.

Landowner- Good faith attempt to eradicate pests - Effect.

Every owner and all owners who, upon receiving said notice as provided in this act, shall proceed and continue in good faith to eradicate and destroy said pests shall be exempt from the provisions hereof as to the lands upon which he or they are so proceeding.

Zone of infection - Dissolution

Whenever the state board of forestry shall determine that control work within the designated zone or district of infestation is no longer necessary, said board by resolution may dissolve said district or zone, and whenever the owners of 60 per cent or more of the lands within said district or zone of infestation shall petition said state board of forestry to dissolve said district or zone for the reason that control work is no longer necessary or feasible, then the said board shall by resolution dissolve the same.

Members of cooperative - Exemption from act.

Every owner in any such zone or district who is a member of a cooperative association of timberlands now existing, or which may hereafter be formed and which actively engages in the destruction, control and eradication of the said insect pests and pine beetles, using methods approved by the state board of forestry, shall be exempt from the provisions of this act.

'Timber lands' defined.

For the purposes of this act any land shall be considered timber land which has enough timber, standing or down, to constitute, in the judgment of the state board of forestry, an insect or pine beetle infestation breeding ground of a nature to constitute a menace, injurious and dangerous to timber or forest growth in the district or zone under consideration.

'Owner' defined.

The word 'owner' as used in this act shall include individuals, partnerships, corporations and associations."

5. Reports on Infestations

In some Regions, the district rangers are expected to make an annual report late in the fall of the insect conditions which prevail in their districts. These annual reports follow a prescribed outline and a definite date is fixed for their receipt in the Forest supervisor's office. The Forest supervisor assembles the reports for the various ranger districts and submits them to the Regional Forester for consideration and further action. Such a procedure has certain self-evident and important advantages over the practice of the preparation of insect reports only when special conditions arise. It is possible that the annual report arrangement will eventually be put into effect in this Region. In the meantime, district rangers and other Forest officers are expected and required to promptly report the appearance of unusual forest insect conditions on the National Forests to the forest supervisor. This procedure is to be followed for all forest insects, as well as the western pine beetle.

In order to insure the inclusion in the report of all salient information regarding the outbreak, the following outline should be used for the description of the infestation. The outline is applicable to outbreaks of all forest insect species.

1. Date of report.
2. Name of Forest officer making the report.
3. Species of trees infested and statement as to part of trees attacked such as:
    - A. Affecting the tree trunks - beetles boring in the bark or wood.
    - B. Feeding on the foliage, particularly caterpillars.
    - C. Affecting the twigs and branches.
    - D. Affecting the growing tip.
4. Character of trees infested, whether large or small, old or young, healthy or sickly, fast or slow-growing, etc.
5. Description of area infested. Include:
    - A. Estimate of acreage infested.
    - B. Legal subdivisions included in infestation, such as townships, sections, quarter sections, etc.
    - C. Names of drainages or portions of drainages involved.
    - D. Map of infestation. Need not be detailed.
6. Estimate of amount of damage.
    - A. Volume of infested timber per section, separated by species. Statement as to what portion of these infested trees will, in your judgment, fail to survive.
    - B. Value and quality of timber infested and threatened.

7. Distribution of damage.
   A. Range of elevation.
   B. Exposures on which damage is concentrated - north slopes, ridge top, etc.
   C. Occurrence of infested trees - single trees, small groups, large groups, etc.

8. Description of the insects thought to be responsible for the injury. Send specimens of the injured or infested foliage, bark or wood, securely packed in a tight wooden or tin box to

   Forest Insect Field Station,
   U. S. Bureau of Entomology,
   Portland, Oregon,

   if there is any doubt whatever as to the species of insects doing the damage.

9. Miscellaneous information.
   A. History of the outbreak.
   B. Status of the infestation, namely whether it is increasing, decreasing, or in a quiescent condition.

10. Recommendations of reporting forest officer, - particularly whether a more detailed insect survey by a specialist is needed, or whether control operations seem to be needed, or whether there is a possibility of disposing of the infested timber through administrative use or sale.

With these reports as a basis, the Forest Supervisor and the Regional office will determine what further action is necessary. If the infestation appears to have dangerous possibilities, the insect control specialist from the Regional office may be assigned to make a special study of the situation.

6. Organization of a Control Project

General considerations

A barkbeetle control project may be defined as an enterprise directed toward the suppression of a forest barkbeetle on a specific area and operating under a definite entomological plan. It may vary in size from one man working to control the beetles on his own land to an undertaking contemplating the control of beetles over many square miles and employing hundreds of men.

Aside from entomological considerations, such a project may be a success or a failure, depending upon the character of its administration. Artificial control is expensive at best, and inefficiency in management may very easily result in costs which can not be offset by the timber saved; while on the other hand a trifling change in methods of management may show a profit. The margin between success and failure is often very narrow.

The organization of a control project naturally divides itself into two parts, viz., (1) entomological supervision and (2) control administration.

The entomological supervision may be considered as analogous to the architectual supervision of building construction or engineering supervision in railway work. Its function is to make the preliminary surveys, draw up the plans, devise the methods and supervise their application. The work may be handled by trained entomologists of either the federal or state department, or in private work by a man specially trained in insect control work. Outside of making the plans, the entomologist will usually not be called upon to handle the actual control administration. It is best that he act only in an advisory capacity in such matters as camp organization, camp personnel and such other problems as have to do with the administration of the work.

The control administration is comparable to that of the building contractor. Following the plans of the entomologist, the administrator is chiefly concerned with getting the job done as efficiently, quickly and cheaply as possible. This work is usually carried on by the owner of the land, his agent or an organization responsible for the protection of the timber. In the case of Forest Service projects, the Forest supervisor has full responsibility for all phases of the administration of the work. The insect control specialist of the Regional office act only in an advisory capacity. In the case of Forests on which insect control is a new activity, he gives special attention to the projects in order that the year-long men without previous experience will know how to proceed and what to do.

The most suitable control organization will have to be worked out for each project, but in any case the responsibility for different phases of the work should be definitely assigned to some Forest officer so as to prevent any conflict in authority or duplication of effort.

Some of the matters which affect the organization of a project have already been discussed in Section 3, beginning on page 53.

As a basis for his administrative plans, the Forest Supervisor has a report on the proposed project which has been prepared by the insect control specialist with the help and advice of the Forest Supervisor. This report covers at least the following matters:

1. Exact boundaries of area to be treated and a map of the area.

2. Brief review of past work, if any, and results.

3. Amount of work to be done.
   - A. Period of work. Desirable opening and closing dates from an entomological point of view.
   - B. Number of trees to be treated.
   - C. Volume to be treated.
   - D. Acreage to be covered.
   - E. Probable number of men required to complete the work in the allotted time.
   - F. Probable cost of the work per tree and estimated total cost of the project.

4. Spotting work.
   - A. Methods to be used.
   - B. Kinds of trees to be marked.
   - C. Character of the records to be kept.

5. Treating.
   - A. Methods to be used.
   - B. Estimate of amount of man power needed.
   - C. Suggestions on amount and character of equipment needed.
   - D. Character of the records to be kept.

Season of Work

If it has been decided to do control work, one of the first considerations is the proper time for its execution. There are two seasons during which control work against the western pine beetle can be undertaken on a large scale - namely, during the spring (March 15 - May 15) and fall (September 25 - December 15). Summer work and winter work have only limited possibilities.

Spring work has the following advantages:

1. There is more and better light for spotting and treating work.

2. Infested trees are easier to discover and spot.

3. Trees are easier to peel.

4. Trees are easier to burn.

However, spring work has the following disadvantages:

1. Frequently many beetles emerge and fly before the control operations can be completed.

2. The work may be cut short by the advent of unusually hot, dry weather because of the high fire danger and rapid emergence of the beetles.

3. Burning becomes more and more hazardous and therefore more expensive as the season advances.

4. The ground is usually soft and transportation to the camps is difficult.

5. Other Forest activities frequently open up about the same time as the control work and make it difficult for the personnel to give the insect control job the same amount of supervision and attention.

Fall work also has its advantages and disadvantages. The advantages are:

1. Most other Forest work has closed down and better men and more supervision are more easily provided.

2. The beetles are destroyed before there is any emergence.

3. Some predators may escape destruction, which are burned in the spring work.

4. The fire hazard is considerably less.

5. Until very late in the season, the transportation to the camps and the woods is usually easy.

6. If for some reason the work is not completed, the winter and spring periods offer opportunity for its completion.

The disadvantages of fall work are as follows:

1. The infested trees are often difficult to find. This affects the rapidity of the spotting work and the treating work.

2. The bark is harder to peel than in the spring work.

3. Frequently the trees are difficult to burn on account of snow and rain. Especially is this the case late in the season.

4. The camp may get caught in a heavy snow-storm and make it difficult and expensive to move out men and equipment,

5. Late in the season, heavy snow may increase the time spent in walking to and from work and between trees. This slows down both the spotting and treating.

Largely because of the better condition of the roads and the lower fire hazard, fall control work has been preferred in this Region for several years.

Size of Camps

Adjusting the size of the control camp to fit the conditions found on any project is a matter which requires very careful planning. A camp either too large or too small to fill the particular needs will very adversely affect the efficiency of the work.

Knowing the acreage to be covered, the number of trees to be treated, length of the operating season, rate of treating per man-day and number of necessary camp sites, the size of the camps and the number of men required can be computed. The following problems of organization should be worked out:

1. Determine the number of laborers required to treat the total estimated number of trees in the specified time. Thus, with 3000 trees to treat in 60 days, it will require 25 men treating 2 trees per day each to do the job.

2. Determine how many spotting crews will be needed to cover the area in the allotted time. This will depend both upon the acreage to be covered and the intensity of the infestation. For instance, under average conditions in ponderosa pine infestations running from 40 to 160 trees per section, one 3-man spotting crew can efficiently cruise one half section per day. So if 30 square miles are to be covered in a 60-day working period, at a half section per day, it will require only one spotting crew.

3. Adjust the laborers and spotting crews into convenient camp units, so that the treating will just keep pace with the spotting, or lag only slightly behind it. By filling in with the other necessary camp laborers, such as foreman, saw-filer, cook, and helpers, the size of the camp to be used is thus arrived at.

Scattered infestations require small camps which can be easily moved, while large camps can be worked to advantage in the treating of concentrated heavy infestations.

A large camp is more efficient and has less overhead expense per man than a small one. Therefore plan to have the largest camp that is justified by the given situation. However, the point may soon be reached where the cost of frequent moves will offset any saving due to reduction in overhead. Camps of from 20 to 45 men have been found to be efficient working units, since this number of men can be handled by one cook.

Although large camps are desirable, it is not well to put in more men than are required to finish the work within the allotted time. Since the working periods are short anyway, the men do not reach their maximum of efficiency until the latter part of the period. Too many men result in a shortening of the working period, with less production per man and at a higher unit cost.

On a large project, with more or less uniform conditions of infestation and topography, it is particularly desirable to standardize the size of the camps, selecting the size that can best handle the average infestation. In this way coordination is secured among all the interrelated parts, such as the size of tents, cook stove, length of dining tables, size of motor trucks, etc. It also simplifies the supply problem, as the weekly supply for all camps will be practically the same.

Location of ~~Camps~~

The considerations that determine the location of camps are (1) central location in respect to the working area; (2) general topography of the region; (3) method of transportation; (4) proximity to roads or trails; (5) available water supply, and (6) intensity of the infestation. Camp sites should be selected with the idea of getting the greatest amount of infestation with the least expenditure of time and money. In the first place, the camp must be centrally located with respect to the work, or located so that the men can walk or be transported to within two miles of their work. Ordinarily the maximum walking distance should not be greater than two miles. This will permit working a 12½-square-mile area around the camp, and for light to medium heavy infestations a block of 9 to 16 sections can often be treated without serious inconvenience. If roads and motor transportation are available, this range may be extended in certain directions. However, the topography and timber boundaries will often limit the area that it is profitable to work from one camp site, and short moves to eliminate the walking are often desirable. If the infestation is heavy, the walking distance should be reduced to a one-mile radius from camp.

In selecting the camp sites, all the local factors will have to be weighed to determine what locations are the most desirable. Often the cost of hauling water or of building roads will have to be weighed against the cost of hauling the men to work, or against the loss of the men's time where the distance of the work from camp makes long walks necessary.

Lists of Equipment

Having determined the size of camp best adapted to the project in question, this becomes the "standard camp", and the next problem is to decide as to the kind and amount of equipment needed, and to adjust all the various items so as to best meet the individual need. An effort should be made to furnish the camp with everything that is essential and with nothing that can be spared, to cut weight down to a minimum and to secure articles that will nest and take up the least possible space. Since camps must be moved frequently, a little thought given to the equipment will save time and expense. Also, if every article of camp equipment is on hand when the camp starts, it will save much grief and lost motion later on. It is hardly advisable to attempt to discuss all the variations that can be made in equipping camps, but the foregoing suggestions may be helpful. The following is a suggested list of equipment for a 23-man camp consisting of:

1 Foreman
1 Cook
1 Flunkey
1 Saw filer
1 Spotting crew of 3 men
16 treaters

Equipment List

1. General camp equipment (for 23-man camp).

23 Cots, army, steel folding, 2'6" x 6'6"
1 First-aid kit, U.S.F.S., standard
24 Files, 8" flat, 1 round edge
1 Grindstone or emery wheel
1 Hammer, claw
5 lbs. Haywire
8 lanterns, standard #2 cold blast
23 Mattresses, 3' x 6'6", cotton slab
10 lbs. Nails, assorted
1 Pick mattock
1 Saw, light carpenter's hand
1 Saw-filing set
4 Stoves, Sibley 24", 24 gauge
4 Stovepipe sets, Sibley, 6 lengths, tapered to telescope
4 Dampers, Sibley stove
4 Tents, army squad, 16x16 with poles
1 Tent, cook, 16x20, 10-oz. duck, 4' wall
6 Wash basins
2 " tubs
1 Wash board
1 small tent for cook and his helper
Extra tents and flies for shelter of tools and saw-filer.

2. Treating crew equipment (for 8 treating crews of 2 men each). This list is the absolute minimum. Additional tools to allow for breakage and loss are desirable.

20 Axes, double-bitted, handmade, 3-3/4-lb. or 3½ lb., swamping pattern
6 Ax handles, D.B. - to replace broken handles.
10 bottles, pint, for coal oil
8 Canteens, gallon, blanket-covered
8 Carborundum Stones, round pocket
8 Rakes, asphalt, lightest weight
10 Saws, 6½-ft., falling (4 cutters to 1 raker)
10 pairs saw handles
8 shovels, L.H.R.P.
8 Sledges, 4-lb., flatface
6 Sledge Handles, to replace broken handles
16 Wedges, flat, thin, 4-lb. falling

3. Spotting crew equipment:

A. Compassman.
1 Geologist's compass with staff
1 Tally register
1 Map of area (½" scale or larger)
1 Book section plats
1 Aluminum holder for plats
1 Carrier sack
1 Army canteen (quart size)
Pencils (4H) and erasers

B. Spotter - for each man.
1 Marking hatchet or light ax (2½ lbs.)
1 Aluminum form holder
1 Carrier sack
1 Diameter tape or Biltmore rule
1 Army canteen (quart size)
Pencils and erasers
Timber crayon
Spotting record forms
Tree tags, tacks, etc.

Description of Equipment

A brief description of the various items of equipment will be of assistance.

Tents. The sizes of tents to be selected will vary from small ones for small camps to large ones for large camps. For large camps it is best to increase the size of the tents rather than their number. The 10x12 tents accommodate four men, and the army pyramidal tents eight men each, without undue crowding. Where transportation is an important factor, tents should be of the lightest duck consistent with durability. With motor transportation, weight gives way to serviceability as the first consideration.

For the cook tent, a tent of white 10-oz. duck with high walls if preferable. Its size will depend upon the number of men to be accomodated. For a large camp, two tents, one for dining and one for cooking, are desirable. One 16x20 tent can be made to accomodate an 18-man camp as a combined cooking and dining tent, but two are more satisfactory.

Stoves: The cook stove should combine adequate top and oven space with lightness, compactness and dirability. The army field range is excellent for the purpose. It "nests" and is comparatively light. It can be used satisfactorily for camps of between 10 and 50 men. Other types of sheet iron stoves are better adapted to smaller camps. For the latter, where transportation is a limiting factor, open fires and Dutch ovens can be used.

For heating the men's tents, nesting sheet iron stoves with flat tops, or Sibley stoves, are very satisfactory. These stoves should be equipped with six lengths of pipe which can be reversed and telescoped to prevent damage in packing.

Cooking outfits: Cooking outfits which will "nest" should be selected, and the whole set kept down to the least possible bulk and weight.

For a dining table top, a handy device is made with a strip of 36" canvas, on which at half-inch intervals laths are nailed. This is then covered with oilcloth and makes a very convenient table top of any length desired and can be rolled up and easily carried when moving camp.

Grindstone: A good grindstone is preferable to emery wheels for sharpening axes, and one should be furnished each camp unless difficulties of transportation make it impracticable.

Record box: Regardless of the size of the camp, a box should be provided for the safe keeping of the records. With very little trouble, one can be provided with shelves or pigeonholes of the proper size to accomodate the various record forms, and the cover so arranged that when open it serves as a writing desk. The Army field desks, if available, are very good for this purpose.

Compass: The geologist's compass with Jacob's staff is the best equipment for the 3-man spotting crew running strips from a base line.

Biltmore Rule: Where great accuracy in diameter measurements is not required, a convenient device for the spotter is a Biltmore rule laid off on his ax handle. With a little practice, measurements can be taken to the nearest two inches.

Saws: In addition to one falling saw for each crew, at least two extra saws should be provided for each camp, so that dull saws can be filed without interfering with the work. The best type of saw for this work is the falling-saw pattern, having four teeth to one raker.

The length of the saw will depend upon the size of timber to be felled. In insect control work, where a number of tools must be carried, the smallest saw that will do the work satisfactorily should be selected. In timber averaging about 12" d.b.h. a 6' saw is satisfactory, for timber averaging about 20" a 6½' saw should be chosen, and for timber averaging 30" d.b.h. a 7' saw or larger will give the best results. Even where the timber runs to small diameters, one or two long saws should be provided in each camp in order to handle such large trees as are encountered.

Axes: A double-bitted ax is the best all-around tool for treating work, with a pattern somewhere between that of a falling ax and a swamping ax. The 3½-lb. ax is the best average weight, although a few 3, 3¼ and 4-lb. axes should be available in each camp for the men who prefer them. Some expert peelers curve the axe handle by steaming it, and are able to remove large sections of bark with a single blow.

Spuds: Barking "spuds" have been used to some extent where the bark does not stick too tightly to the tree. These consist of a short, slightly-curved piece of steel about 3 inches wide and a foot long, sharpened at one end and set into a short, stout handle, or into a long handle for the peeling of standing trees. But since an ax has to be carried anyway, the barking spud is usually of not enough value to bother with as an extra tool.

Wedges: The thin 3½- to 4-lb. falling wedges are the best for the purpose. Each treating crew should carry two of them.

Sledges: The sledgehammer does not often come in for heavy service and so should be as light as possible. The 4-lb. sledges are usually considered heavy enough.

Carborundum stones: The circular pocket stones are the best.

Files: Eight-inch flat files with one round edge should be purchased for the use of the saw-filer, and when slightly worn can be given to the treating crews for use in touching up their axes if nicked by rocks or pitch knots.

Fire rakes and shovels: Fire rakes should be the lighter make of iron asphalt rakes. The long-handle round-point shovels are satisfactory for constructing fire lines where the rakes can not be used. The McLeod fire tool is a combined rake and wide-bladed hoe, and is excellent for fire-line construction if available.

Personnel

The camp foreman should be not only thoroughly trained in the practical aspects of insect control but particularly well qualified in the art of handling men. He should understand the psychology of labor, know how to apply it, and understand all phases of the work so that he will know whether or not it is being properly done.

The administrative efficiency of the work depends largely upon the camp foreman.

The spotters should preferably be active young men with observing eyes and alert minds. They must be ready and willing to do a lot of walking in scouting out the trees and must exercise considerable good judgment in the marking. Familiarity with compass work, pacing and the methods of land survey are an asset. The spotting crew should be administratively responsible to the camp foreman for their work - where, when and how much. In addition they should be held accountable to the entomologist for the technical character of their work, i. e., the kind of trees they mark for treatment.

The compassman should be expert at pacing, neat and accurate in mapping, and familiar with the methods of land survey. An accurate map very materially increases the efficiency of the work by reducing the chance of the treating crews missing the trees. A good compassman is an asset, but a poor one is a decided liability.

The cook is a most important man in the camp organization. Here again it is false economy to get a poor though cheap cook. He will soon offset the saving in wages by the food he wastes, by the discontent among the men and the consequent decrease in production. If the camp consists of more than six men, a cook is needed; but one cook with a few helpers can also take care of a hundred-man camp. Therefore the larger the camp, the less the overhead for cook and helpers.

When a camp has more than five crews, a saw-filer is a necessity. For the smaller camps a saw-filer can often be found who will file saws part time and work in the woods when the saws are in shape. Here again a good man is an economy.

The woodsmen employed as treaters on insect control work must not only be faimilar with the use of an ax and falling-saw, but must be husky and capable of making long walks and doing considerable climbing, as often the most arduous part of the work is getting to the infested trees. Experience has shown that the best type of labor for this work is the local farmer or woodsman. Regular "lumber jacks" have for the most part proved unsatisfactory. They are a highly specialized class of workers and dislike the various jobs connected with peeling and burning the bark, which they consider "out of their line". They also object to the long walks. On account of the walking, young men are usually better fitted for the work than older ones, although many very excellent workers among older men have been employed in the camps.

Miscellaneous administrative considerations

Wages: The foreman, cook, cook's helpers and spotters are usually paid on a monthly basis, the others on a day basis.

Bonus or contract systems of paying the men, on the basis of the amount of work accomplished, have at times proved very satisfactory.

Subsistence: The subsistence problem will vary considerably with the type and size of camp, character of transportation and the ideas of the cook. The men require good substantial food, well cooked and in sufficient quantity, and with a reasonable amount of variety. For the sake of economy, the use of canned goods would best be cut to the minimum, fancy brands of groceries avoided, and fresh meats and vegetables supplied whenever possible. The work is usually so far from camp so that midday lunches should be taken instead of having the men come to camp for dinner. In this connection it has been found that the most economical and satisfactory procedure is for the men to put up their own lunches from cooked foods set out on a serving table by the cooks. In this way each man can get just what he wants, both as to items and quantity.

Transportation: The transportation problem will vary from the use of pack animals to teams and wagons or motor trucks, depending upon local conditions. The cost of hiring transportation on a contract basis versus the purchase of motor trucks or other alternatives should be carefully weighed to determine what will be the most economical in the long run. If pack stock is used, the number should be cut to the minimum, as there will be very little work for them after the camps have been established. Teams are sometimes less expensive than motor trucks, but their use is limited to the moving of camps and the hauling of supplies. For a small camp they are often very satisfactory.

If motor trucks can be used, they have the advantage of speed in moving camps and supplies, and between times can be used advantageously in transporting the men to the more distant parts of the work. In this way considerably more acreage can be can be covered from one camp set-up than if the area were limited to what could be reached by walking.

On a large project, with operations extending over more than one season, it will undoubtedly pay to purchase motor trucks if they can be used advantageously. The lighter trucks, with capacities of 1500 and 2000 pounds and speeds up to 35 miles an hour, are very suitable for this work. The use of the trucks should be carefully watched by the foreman to see that they are not used more than necessary. One trip to town per week for supplies is ample, provided the cooks are trained to anticipate their needs a week in advance.

Communication: It is very desirable to have telephone communication between camps and the control office. If established telephone lines run within three or four miles of the camp, this can be arranged by using light emergency telephone wire and the portable field telephones used by the Signal Corps. It is probably not worth while to put in telephones if the existing lines can not be reached within a three- or four-mile radius.

Some administrative suggestions: Do not attempt control unless the area is isolated from other epidemic attacks and can be completely covered by control work before the beetles emerge.

Before starting the work, make a complete plan so that every item will be provided for. Make complete lists down to the smallest detail of all camp equipment to furnish one standard camp. Be sure all items are available before assembling the equipment, then upon gathering it check against the lists to be sure that nothing is missed.

Large camps are more efficient than small ones, therefore plan to have the largest camp that is warranted by the given situation rather than several small ones.

Plan the spotting and treating work so that they will progress uninterruptedly from one side of the project area to the other. Do not skip around from one section to another, as this causes much lost motion, extra work for the men in carrying their tools over unprofitable distances, and will result in leaving little patches of work to be cleaned up at considerable extra expense.

Plan the work so that it will progress toward the next camp site. When moving day comes, the crews will then be at the furthest edge of the old territory and can easily walk in from work to the new camp site. This prevents time being lost in the field, due to the moving, and avoids the expense of transporting the men by trucks.

Start the work on a small scale, and then increase the size and number of camps as rapidly as they can be efficiently handled.

The cost of control can very easily be increased by an excessive amount of overhead. Watch this and keep the non-effective labor operations to a minimum.

Avoid too many bosses. The men should receive instructions and take orders only from the camp foreman. The spotters, the entomologist and others should refrain from making any comments directly to the men when they are observing or inspecting the work. All changes should be taken up through the camp foreman; otherwise a good deal of confusion will result and the men will not know whose advice to follow.

7. Spotting

A spotting crew is composed of three men, one compassman and two spotters. The compassman is the leader of the crew and upon his skill, energy and judgment depends the amount and quality of the work accomplished. The compassman should, preferably, be young and active. He should have the ability to run a compass, pace distances and map the relative positions of bug trees and topographic features with a high degree of accuracy.

It is said that it takes several years for a man really to become skillful at spotting bug trees. He should have keen eyesight, youth and energy, and should have the ability to exercise good judgment. He must know the different species of beetles, their appearance, life history and habits, and he must know the various symptoms of beetle infested trees. Before a man ever tries to spot, he should have at least one season's experience at treating. No hard and fast rules for the identification of bug trees may be made; the skill of the spotter depends upon his native ability and the extent of his past experience.

To illustrate how a spotting crew works, suppose, for an example, that the crew is starting to work in section 10 in township 37 south, range 13 east. In this case they will run strips north and south across the section. They could run the strips east and west, but the weather is bright and clear and the spotters would be at the disadvantage of having the sun directly in their faces at times. They will start, in this case, at the extreme southwestern corner of the section.

Starting at the section corner, the compassman paces due east to a point one tally (five chains) along the section line. From this point he starts due north, taking frequent compass sights to run a true line, and keeping accurate count of the paces, chains or tallies as he progresses, so that at any time he may stop and instantly and accurately plot his relative position on the map or section plat. The spotters range about on both sides of the compassman, each covering a strip of timber one tally in width. Suppose, in this instance, that A. is on the right and B. on the left of the compassman.

The compassman should always try to keep about even with the spotters; he should never set such a fast pace that he leaves them behind. The spotters must have time to carefully inspect their strips as they progress. At the end of each tally the compassman calls "Tally one", "Tally two", etc., on up to "Tally sixteen, the end of one mile. Calling the tallies serves a double purpose, it enables the spotters to check the compassman if he has made a mistake in the distance, and it helps the spotters to keep track of the compassman and of each other when the brush or reproduction is so thick that it obscures the view through the timber.

As the compassman proceeds he spots on his 8-inch to the mile scale section plat the relative position and proper consecutive number of each bug tree spotted by the spotters. He also maps in topographic features, such as streams, dry draws, rim rocks, openings in the timber, roads, telephone lines, etc., anything that will aid the treating crews in finding the bug trees. He should check in on all section and quarter corners. At the end of one of one half mile, or 8 tallies, in section 10 the compassman should pace one tally west to find the quarter corner between sections 9 and 10. At the end of one mile, or 16 tallies, the compassman should be very nearly on the north line of the section, about one tally to the east of the northwest corner of section 10. A good compassman, provided there is not too much brush or snow, should pace within one chain (66 feet) of the proper distance, and should be within one chain of the proper alignment on his compass line.

After checking in on the northwest corner of section 10, and making such corrections on his map as are necessary, the compassman offsets two tallies more to the east, to a point three tallies east of the corner, and starts another line to the south through the section. A. still works to the right and B. to the left of the compassman; the spotters always keep their relative positions so that they can connect up with the work that they did on the previous strip. At the end of the 16 tally run to the south the compassman should check in on the south line of the section, at a point about 3 tallies east of the southwest corner, the point of beginning. From here another offset of two tallies to the east is made and the crew starts back north across the section. When section 10 is completed the compassman will have crossed the section with eight compass lines, and the spotters will have made a one hundred per cent inspection of the timber on all of the 640 acres of the section.

To illustrate the methods of the spotters, suppose that B. observes on his strip a group of pines with faded, sickly foliage, and, as he approaches, he notices that the bark has been freshly drilled and riddled by the woodpeckers, an unmistakable sign that beetles, probably western pine beetles, are present in large numbers. Upon arriving at the trees he samples them (chips into the bark) with his axe and satisfies himself that western pine beetle larvae are present in large numbers in the bark. He immediately shouts "bugs", whereupon the compassman stops, orients his map and spots on the position of the bug trees. Meanwhile B. is busy marking each infested tree by means of large blazes, chopped about four and one half feet from the ground, on three or four sides of the tree. He closely inspects the surrounding green trees for evidences of fresh woodpecker work, pitch tubes, sawdust in the crevices of the bark, anything that will indicate that beetles have attacked. Any tree that shows suspicious symptoms he will sample with his axe, being careful not to injure the cambium layer of the tree. When B. is certain that he has all of the infested trees spotted, the compassman will call to him the number of the next tree, say 1541. Upon a blaze on each of the infested trees B. will mark a number and his initials, with timber crayon, in this manner: $\frac{1541, 1542,}{WR \quad WR}$ etc.* Supposing that

*The spotters tack a numbered tag on each infested tree. These tags are subsequently removed by the treating crews and brought to the camp foreman each night as evidence of the completion of the treatment of the trees.

there are ten trees in the group, B. will call back to the compassman "ten trees, fifteen forty one to fifteen fifty". The compassman records the group on his map in this simple manner: 1541 - 50. The next tree will be numbr 1551.

This procedure is followed every time that a spotter finds a beetle-infested pine. Sometimes it is not nearly so easy for the spotters to detect a bug tree; the tree may be by itself, in the midst of healthy trees, and may show scarcely any fade at all, and no woodpecker work. The spotters attention may be attracted by the presence of a few fresh pitch tubes and the evidence of sawdust (fresh bug borings) in the crevices of the bark.

The speed at which spotting work progresses depends upon the number of bug trees, the density and character of the undergrowth and the roughness of the topography. Each crew should average about one half section, 320 acres, per day in its spotting work.

The equipment of a spotting crew consists of the following:

1 staff compass with staff.
1 tatum holder
1 tally register
2 2½-pound double-bitted axes or single-bitted axes for marking the bug trees.
3 belt canteens
Map sheets, pencils, erasers, crayon, spotting forms, etc.

The records of the spotting crew consist of:

1. Spotting record of individual trees. This is placed on a regular printed form, ruled off in such a way that there is space for 20 to 25 trees on each sheet. The data entered for each tree to be treated consist of:

A. Number of tree.
B. Diameter.
C. Number of 16-foot logs and board foot volume.
D. Location of tree by forty and section.

2. Maps of the sections covered by the spotting work on the scale of eight inches to the mile. Extra copies of the original are made on the same scale for the use of the treating crews.

3. A spotting progress map. This consists of a township map on the scale of one inch to the mile, Forest Service Form 974. On this map the number of trees to be treated on each 40 acres is entered. As each forty is treated, it is colored in red. A study of this map enables the foreman to plan his treating work to best advantage.

4. A spotting progress record. This is a daily tabulation which shows the number of trees spotted each day, the acreage spotted each day, the total amount of spotting completed, and the acreage still to be spotted. A study of this form gives the necessary information on the progress of the spotting.

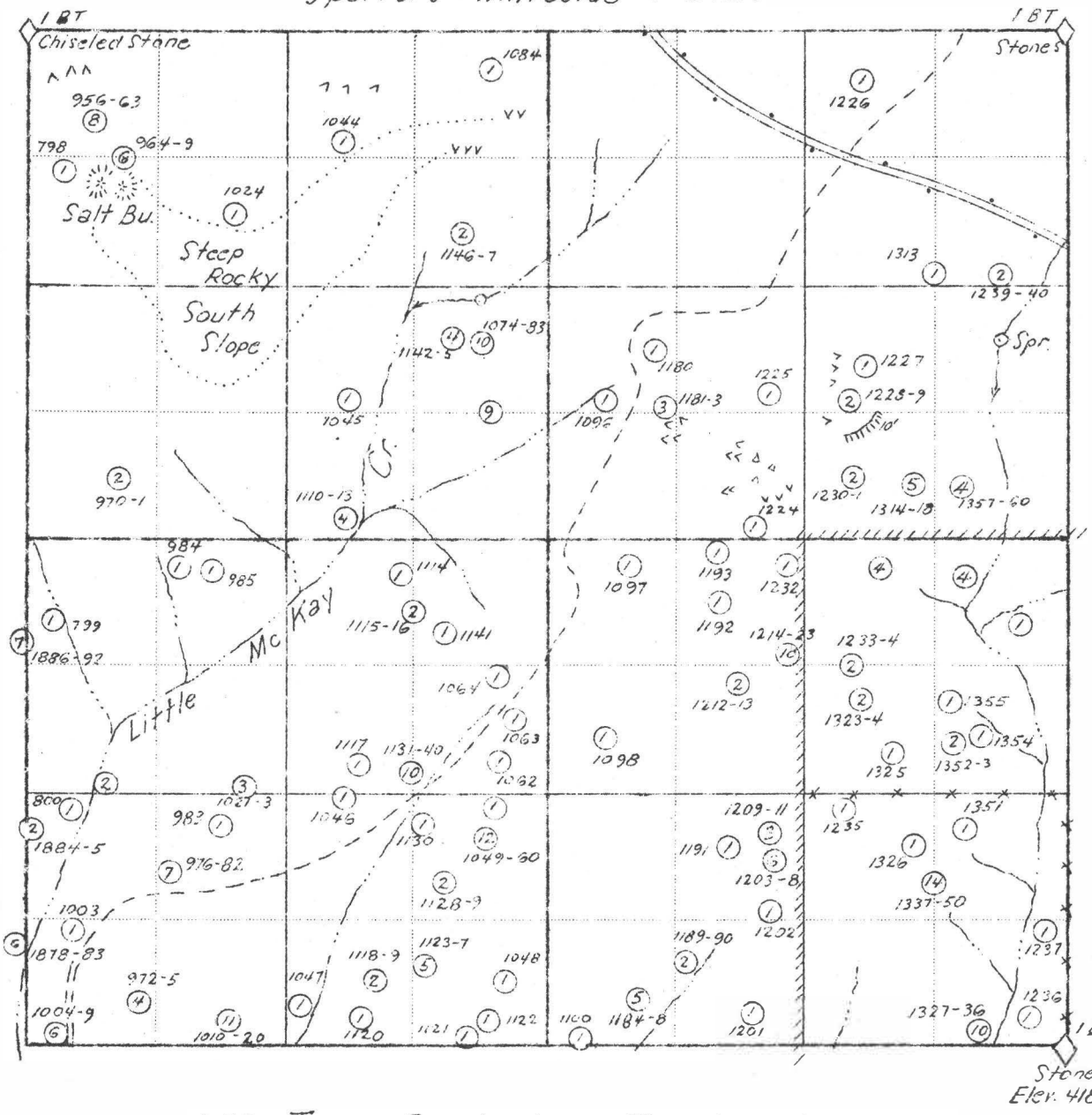
The character of the spotting record described under heading Number 1 is so self-evident that it need not be discussed further. It is a printed form which is easy for even the inexperienced man to understand. A sample of a compassman's section map on the original eight-inch scale, a sample of a spotting progress map and a sample of a spotting progress record (Numbers 2, 3 and 4 in the previous paragraphs) are shown, in the order stated, in the following three pages. On each of the three forms, the necessary explanation for their use and a few words regarding their value are given.

Form One

Project McKay Creek - Ochoco N.F. Unit Salt Butte Camp no. 2

Date Nov. 3, 1932 Compassman O.L. Lynch T. 12 S. R. 17 E Sec. 34

Spotters - Whiteside - Francis



Remarks: 243 Trees Spotted for Treatment

Forties - NESE, SESE are privately owned

Note: This map shows one full section of 640 acres. It was reduced to 6x6 inches from the regular scale of 8 inches to the mile on which such maps are always made.

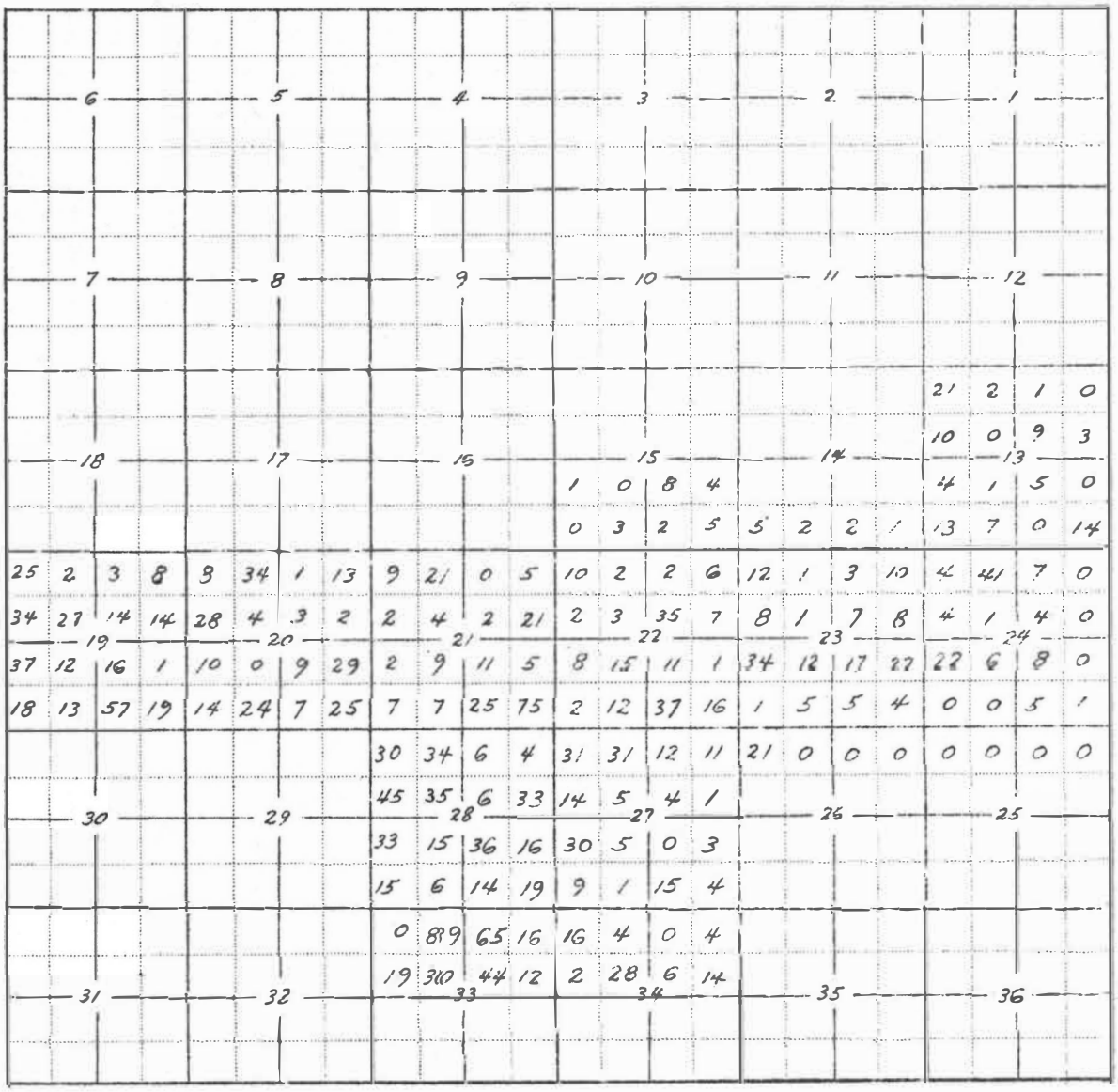
Pages 39 - 50 of the R-6 "Guard Handbook" of April 1, 1933 give valuable information on map legend, land surveys and field markings, which should be referred to by all compassmen engaged on insect control work.

SPOTTING PROGRESS MAP

Form Two

Ochoco (National Forest) | McKay Creek (Project) | Divide Camp (Camp)

T. 12 S. R. 17E Willamette Mer.



The number in each 40 is the number of trees spotted for treatment in that forty. The information is secured from the 8" x 8" maps of each section prepared by the spotting crew.

Each day the forties which have been treated are colored on this map. By reference to the map, the camp foreman is able to plan the treating work for days and even weeks ahead provided that the spotting has been done sufficiently in advance of the treating.

Form Three

SPOTTING PROGRESS RECORD

Ochoco (Forest) | McKay Creek (Project) | Old Dry Creek (Camp) | 3400 (Total acreage to be spotted)

Date 1932	Previously Spotted		Spotted Today		Total Spotted		Unspotted Acreage	Number of Spotting Crews	Crew Leaders.
	No. of trees	Acreage	No. of trees	Acreage	No. of trees	Acreage			
Fri. Dec. 2	0	0	129	560	129	560	3400	2 Crews	Lynch & Schlegel
Sat. Dec. 3	129	560	245	720	374	1280	2680	2 Crews	Lynch & Schlegel
Sun. Dec 4	374	1280	226	640	600	1920	2040	2 Crews	Lynch & Schlegel
Mon. Dec. 5	600	1920	99	640	699	2560	1400	2 Crews	Lynch & Schlegel
Tues. Dec. 6	699	2560	136	520	835	3080	880	2 Crews	Lynch & Schlegel
Wed. Dec. 7	835	3080	57	320	892	3400	560	1 Crew	Lynch

Explanation:

The figure in the column headed "unspotted acreage" is secured by subtracting the "total spotted acreage" from the acreage estimate given in the heading at the top of the form which reads "total acreage to be spotted". The other columns are self-explanatory.

This record helps the camp foreman to make rough answers to such practical questions as:

1. When will the spotters complete their job?
2. How many trees will require treatment and how does this compare with the number of trees on which the allotment estimates are based?
3. Will one or two spotting crews be needed to keep well ahead of the treating work?
4. How many men will be needed to finish the treating work within the allotted time? (The average daily production per man per day enters

8. The Treating Work

The method of treatment most commonly used in western pine beetle infestations in ponderosa pine is the so-called peeling and burning method briefly described on page 52 of this manual. A more detailed description of the application of the method is given in the paragraphs to follow.

Method of treating

Felling: Wherever possible, the trees should be felled in an open place, where their treatment will cause the least possible damage to reproduction and green timber. In order to simplify the work of the limbers, the trees in a group should be felled with the trunks parallel; this also simplifies the rolling of the logs into piles. If possible, stumps should be cut close enough to the ground so as to include nearly all of the infested bark. On sloping ground the trees should be felled downhill or uphill and never on the contour, as otherwise the fire will be hard to control. "Bedding" heavy logs - i. e., keeping them off the ground by laying down poles or logs on which they may rest - is sometimes desirable when burning conditions are unfavorable and it is necessary to place pitch and dry material along the under side of the logs to create a draft and insure complete burning of the bark.

Limbing: After each tree is felled it should be limbed, and the limbs cut off very close to the trunk. This is not only easier to do than to leave a stub, but it saves barked knuckles when the trees have to be peeled and simplifies the rolling when the trees are burned in piles.

Piling: When trees occur in groups they should be thrown together and burned in piles. The size of the pile will be determined by the number of infested trees closely adjacent and the amount of space available in which to burn them. When the open space is limited, the piles should be kept close to the ground in order to reduce the size of the fire. In order to secure a good burn, the logs should be piled parallel and close together, with plenty of inflammable material on the ground. After the piles are formed, the limbs are usually thrown back over the logs and the tops cut off and brought back over the piles in order to dispose of the slashings. When burning in piles, it must be remembered that the infested bark must be completely burned. If this complete burning of the bark can not be secured by burning in piles, the peeling and burning of the individual infested trees must be resorted to. Burning in piles is a time-saving and money-saving method but there is danger of incomplete burning of the infested bark unless the method is skilfully used.

Peeling: When the peeling of the trees is necessary, all infested bark on the top half of the log and well down on the sides should be removed and stacked along the log. The peeling should continue far enough into the tops so that the burning of the tops, brush and limbs will destroy the beetles in the remainder of the trunk. Usually this means peeling the logs to below a 20-inch diameter limit. Infested bark below 10 inches from the ground should not be peeled and burned.

Brush disposal: In order to conform to good forest practice and reduce the fire hazard, the brush and slash from control work should either be burned or spread out where it will decay as soon as possible. In wet weather the limbs and brush should be piled over the logs and burned with the bark. In late spring or early fall, when the forest is dry, the brush should be scattered outside the fire lines and kept out of the fire. Disposing of brush by burning in separate piles adds 25 per cent to the cost of the work.

Burning: The fire should be large enough to burn completely all the infested bark, and yet not so large as to make it difficult to control or to cause damage to adjacent standing timber. This can largely be regulated by the amount of material left within the fire lines. Under wet conditions, the placing of pitch or other dry material along the trunk often becomes necessary in order to secure a satisfactory burn.

As the ground cover dries out, a fire line becomes necessary, and should be constructed just as soon as there is any tendency for a fire to remain active over night. It should be made as close to the tree as is compatible with safety in burning. The line itself should be a cleared path at least two feet wide, raked or shoveled down to the mineral soil, and should completely encircle the tree but exclude the stump. This precaution regarding the stump is advisable since many predaceous insects pupate in the soil at the base of trees containing advanced broods of the beetles, and, by preventing the burning of the debris around the stumps, these insects are saved. To prevent basal injury to standing live trees within the fire line, all needles and debris at the base of such trees should be removed. Under very dry conditions, fires should be started on the uphill or leeward side of the trees on the edge of the fire line, and the trees burned by "backfiring" down the hill or against the wind. Under these conditions it is often best to burn the trees only early in the morning or in the late evening, when the wind and humidity do not add materially to the fire risk.

By regulating the amount of material to be burned and the width of the fire line, burning can be done at any season of the year and on the most hazardous areas without injury to the rest of the forest. However, summer burning is not advisable, both because of the extreme danger and excessive expense involved in handling the fires, and the poor results secured from summer work in controlling the beetles. When burning of the tops and limbs will cause injury to standing trees, it is best to run the fire line under the log so as to exclude the top of the tree, and construct the line close to the tree so that only the infested bark will be burned. In this case, the fire should be started

at the point where the line crosses under the log, so that it may be made certain that the fire does not jump into the top before the tree is left unguarded.

Allowing fires to escape is usualy an indication of careless or poorly-planned work. It takes considerable experience and skill to burn during dry weather without danger to the forest, and new crews must be given a great deal of supervision. Therefore the plan of having special crews do the burning whenever the situation is at all hazardous and the bulk of the labor inexperienced in control work, is a good one.

Size of treating crew

In ponderosa pine control operations, the usual size of the treating crew is either a two or a three-man crew. A two-man crew is best suited to treating work when fire lines do not have to be constructed. It is not difficult to divide the men into congenial pairs, "partners", or men of equal ability. This makes for efficiency; it also makes it easier to tell if any man is loafing on the job, as the results will be quickly evident. A three-man crew is best adapted to the treating work when fire lines have to be constructed. Two of the men fell, peel and prepare the trees for burning, while the third man constructs the fire line and takes care of the burning. The third man is needed in this case to assist in carrying the extra fire tools.

When the infestation is heavy and the crews can be worked closely together, a system of dividing the work into specialized jobs has occasionally been used. Under this system, expert timber fallers do the felling of the trees, buckers and limbers do their part, a peeling crew removes the bark, and then a fire crew comes in to handle the burning.

Equipment of each treating crew

The equipment of a two-man treating crew is as follows:

One 6½-foot falling saw
One or two 3-pound falling wedges
Two 3½-pound double-bitted axes
One bottle of saw oil
One 6-pound sledge
One canteen - one gallon size
Two saw handles
One hand carborundum stone
Treating map, crayon, matches, etc.

When the weather becomes dry and it is necessary to trail the fires, another man is added to the crew and the following additional equipment is needed:

One fire rake
One or two shovels
One additional 3½-pound double-bitted axe
One additional canteen

Use of treaters' maps

Each treating crew is supplied with a copy of that portion of the eight-inch map of the section showing the timber which has been assigned to the crew for treatment. As has already been explained, these maps show the location of the infested trees and all topographical and other features of the country which will assist the crew to locate the infested trees. Because the infested trees may have green foliage and are therefore difficult to see from a distance, an accurate and detailed map is a big time-saver. The leader of the crew should know how to read maps. During cloudy weather or in brushy country, a pocket compass is a valuable help.

Records kept by treating crews

The leader of each treating crew removes the numbered tag from each infested tree that is treated. On each numbered tag, he places his name or his crew number. These tags, together with the map, are brought to the foreman each evening. They enable the foreman to determine what trees have been treated, what trees are still untreated and how much work each crew is doing. On the stump of every treated tree, the crew leader writes the number of the treated tree which appears on the tag and writes his name. This practice makes it possible for the foreman to identify the work of his crews in the woods and to check the quality of the work done by them.

Camp records

In each insect control camp, the records are of three general kinds, as follows:

1. Spotting records. These have been described in detail under the "Spotting" heading.

2. Time records, property records, meal records, etc. These are self-explanatory and are similar to those used in all Forest Service camps. For this reason, they need not be described.

3. Records on production of work. These records are needed in order to enable the foreman to follow the progress of his treating work and to give him the answer to such practical questions as to whether he has enough man-power to finish the job in the allotted time, whether the daily production of work is falling below the volume on which the allotment estimate was based, the approximate date on which the project is likely to be completed, etc. In order to simplify the keeping of the necessary "production of work" data, two forms of tabulation have been found by experience to serve all of the needs. These two forms are called the "Daily Individual Treating Crew Record" and the "Daily Camp Treating Record". Samples of these two records are given on the

next two pages of the manual, together with the necessary explanations for their use. Any one at all familiar with western pine beetle control work, can understand the necessity for keeping these two daily production tabulations.

Form Four

Daily Individual Treating Crew Record

Ochoco (Forest) — Mc Kay Cr (Project) — Old Dry Creek - Camp 3 (Name or number of camp)

Crew Number

Date 1932	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	Total No. of Trees treated by all Crews	Man Days
Tuesday Dec. 6		5 (2)	10 (3)	14 (3)	7 (2)	9 (2)	6 (2)	10 (3)	6 (2)	67	19
Wed. Dec. 7		5 (2)	10 (3)	21 (4)	11 (3)	9 (2)	10 (2)	9 (2)	5 (2)	80	20
Thurs. Dec. 8	6 (2)	6 (3)	7 (2)	6 (2)	4 (2)	5 (2)	10 (2)	6 (2)	5 (2)	55	19
Friday Dec. 9	6 (2)	8 (3)	4 (2)	8 (2)	6 (2)	6 (2)	8 (2)	11 (3)	3 (2)	63	20
Sat. Dec. 10	8 (2)	6 (3)	6 (2)	6 (2)	4 (2)	5 (2)	5 (2)	5 (2)	8 (2)	53	19
Sunday Dec. 11	0	0	0	0	0	0	0	0	0 (0)	No work	0
Monday Dec. 12	6 (2)	8 (2)	7 (2)	8 (2)	4 (2)	6 (2)	7 (2)	8 (2)	10 (3)	64	19

Crew No.	Boss	Helper
1	Becker	Gilchrist
2	Hall	Wells
3	Symons	Fincher
4	Taylor	Boyd
5	Birdsong	Houston
6	Coshow	Hawkins
7	Coiner	Nizer
8	Hein	Demaris
9	Young	Huff

Explanations:

The table gives the number of trees treated each day by each crew. The numbers in the circle represent the number of men who worked that day in the crew. Each crew has a permanent number. In most cases, 2 or 3 men work in each crew. The boss or leader of the crew is responsible for the work of himself and his helpers. In the personnel tabulation, only the names of the more or less permanent members of the crew are given.

For example, from the two tabulations, the following information can be deduced: Crew number 2 treated 38 trees during the 8-day period December 6-13, inclusive, with 15 man-days (total of numbers in circles) of labor - Hall is foreman of the crew and Wells is his helper. During the same period, Crew 3 (Symons) treated 42 trees with 14 man-days of labor. The tables assist the camp foreman to follow the progress of the work of his crews.

Form Five

Daily Camp Treating Record

Ochoco (Forest) | McKay Cr (Project) | McKay Cr - Camp 2 (Name of Camp or Number) | Nov. 21 - Dec. 4. 1932 (Period of Work)

Date 1932 (1)	No. of trees previously treated (2)	No. of trees treated today (3)	Total No. of trees treated (4)	Total No. of treated Spotted (5)	No. of trees untreated (6)	No. of men treating today (7)	No. of other men in camp today (8)	Total No. of men working in camp today (9)	Average No. of trees treated today per treater (10)	Remarks (11)
Monday Nov. 21	0	147	147	1729	1582	46	16	62	3.2	First day treating
Tuesday Nov. 22	147	153	300	1886	1586	46	18	64	3.3	
Wed. Nov. 23	300	180	480	2126	1646	54	14	68	3.3	
Thur's Nov. 24	480	165	645	2203	1558	55	13	68	3.0	
Friday Nov. 25	645	176	821	2313	1492	55	13	65	3.2	
Sat. Nov. 26	821	186	1007	2434	1427	53	13	68	3.5	Raining in P.M.

Column 1. Self-explanatory.
Column 2. The total number of trees treated exclusive of today.
Column 3. Number of trees treated today.
Column 4. Total of 2 and 3.
Column 5. Entered daily by leader of spotting crew. When spotting has been completed this number remains the same each day. While spotting is in progress, the number changes each day.
Column 6. This represents the number of trees still to be treated from this camp site, and is the difference between 4 and 5.
Column 7. Includes only the men who are actually treating timber.
Column 8. Includes foreman, cook and helpers, saw filer, spotting crew, road men, truck driver, etc.
Column 9. Total of columns 7 and 8.
Column 10. Result of dividing the number of men treating timber (column 7) into the number of trees treated today (column 3).
Column 11. Weather conditions and other conditions affecting progress of work.

9. Reports

Upon the completion of the control project, the camp foreman turns over all the records to the Forest officer under whose jurisdiction he has been working. With these records as a basis, a report of the project is prepared by the Forest officer responsible for the general administration of the insect control job.

This is a job which should be definitely anticipated and provided for on the Forest. For the sake of completeness and ease of study, it is suggested that the report follow the outline which is given. The report need not be detailed. However, an effort should be made to include all the data asked for in the outline. This will not be difficult if the spotting records and treating records have been kept in the manner and on the forms described in this manual. The outline suggested for the report is as follows:

Outline for report on insect control project

1. Name of project
2. Area
   - A. Acreage planned for treatment.
   - B. Acreage actually treated
   - C. Map of area on scale of not less than one half inch to the mile, showing:
     - a. Treated area.
     - b. Area on which treating was planned but not completed.
     - c. Differentiation of treated and untreated areas according to National Forest, other federal or state lands, private ownerships, etc.
   - D. Estimate of timber volumes by species on treated and untreated acreages.
3. Brief history of infestation prior to control work.
   - A. When and by whom first discovered and reported.
   - B. Estimate of volume and quality of timber killed up to time of control work. Separate the estimate according to species.
   - C. General characteristics of infestation - rapidity of spread and increase, species of insects responsible for losses, etc.
4. Organization of control work.
   - A. Cooperation with timber owners and other agencies
   - B. Description of camps - particularly their size, location, dates of establishment and moving.
   - C. Dates of opening and closing of work on project.
   - D. Working conditions encountered, such as weather, condition of roads, accessibility of the area, etc.
   - E. Description of camp personnel and wage schedule.
5. Character and amount of work done.
   - A. Description of spotting method used. Number of trees and acreage spotted per day per man in spotting crews.

B. Description of treating method used. Number of trees and volume in board feet, treated per man per day by the treating crews.

C. Tabulation of number of trees spotted and number of trees treated on each section, and the acreage in each section covered by the control work.

D. Total number of man days of temporary labor stated separately for the various classes of work such as treating, spotting, etc.

6. Total cost of the work - segregated by the following items: -

A. Cost of all temporary labor - including foremen, cooks, flunkies, spotters, saw-filers, compassmen, treaters, etc.

B. Cost of contributed time (not charged against project).

C. Expenses of men listed in B (may or may not be charged against project).

D. Cost of subsistence supplies.

E. Cost of equipment purchased and charges for all equipment rental, except truck rental.

F. Cost of transportation - gasoline, oil, truck drivers, rental of trucks, etc.

G. Miscellaneous - not covered by items already stated.

H. Total cost of project:

a. Amount expended from special insect control allotment.

b. Contributed time and expenses not charged against insect allotment (total of B and C).

7. Average costs - exclusive of contributed time and expenses.

A. Cost per tree treated. If timber owners and other agencies also did control work in the area, their costs per tree should be stated if they can be secured.

B. Cost per thousand board feet treated.

C. Cost per acre treated.

Section Three

Work Plan for the Establishment and Measurement of Sample Plots in Western Pine Beetle Infestations*

(Pages 90-97 inclusive)

This section gives a work plan for sample plot work in ponderosa pine areas infested by the western pine beetle (Dendroctonus brevicomis). Such sample plots are frequently of help to determine whether an infestation is in a decreasing or an increasing status. For this reason, they are of use in decisions on the desirability of control operations. When the plots are used for this temporary purpose, there is no necessity for carefully marking the boundaries of the plots nor for the taking of increment cores and height measurements or for the use of a chain or tape. When plots are intended only for determining the need of control work, the data listed under 2, 3 and 4 in section G on page 92 can be omitted. All the information asked for in section H will be useful for even the temporary plots. If the compassman has had considerable pacing experience, a chain or tape need not be used for the temporary plots. However, for plots intended for more permanent purposes, such as following the progress of treated or untreated beetle infestations through a series of years, the various refinements and the various kinds of data listed in the work plan must be provided for.

The value of the insect loss data secured from these plots depends largely upon the ability of the spotters to separate the beetle losses by years and to recognize the difference between the attacks of the summer generation and winter generation for the current year and previous year. On pages 95-97, the characteristics of the insect-killed trees are described to assist the spotters in this matter.

*Extracts from the R-6 Forest Insect Handbook of April, 1933.

Work Plan for the Regional Bark-Beetle Study.
Bureau of Entomology-Forest Service

A. Purpose of study

Wherever timber values warrant the expense of protection from barkbeetles, the prompt detection of incipient outbreaks will greatly reduce the cost of suppression. Such early detection is analogous to that of a forest fire lookout detection system. The duty for making these early reports rests on the men immediately responsible for the protection of the forest. To do this detection work properly requires some knowledge of the barkbeetles that are likely to cause epidemic losses, the ability to recognize infested trees, the information necessary to recognize an increase in infestation, and some training in the estimating of timber and timber losses.

As a help to keep close watch on areas in which there is a high beetle hazard, the establishment and annual remeasurement of sample plots is invaluable. However, such plot work serves other purposes as follows:

1. To give forest officers the field training which will enable them to meet their responsibility in insect detection and barkbeetle control work.

2. To give definite information on particular sample plots in areas of high beetle hazard which will serve as yardsticks with which to estimate the severity of infestations in nearby or surrounding areas.

3. To give a long time record of barkbeetle losses and trends. Such data are needed for relating climatic and silvicultural conditions with barkbeetle outbreaks. Such correlation is necessary to reach a better understanding of the reasons for the increase and decline of epidemics and to what extent epidemics can be prevented or or treated by forest management.

The ability to recognize field conditions that favor the building up of barkbeetle infestations has a very definite application in forestry. Little argument is needed to demonstrate that control work against barkbeetlesis much more profitable if infestations are taken in hand at the inception of the epidemic condition rather than after they have reached their maximum.

To put barkbeetle sample plot work on a standard basis throughout the Region, the following instructions have been prepared.

B. Areas to be included

The sample plot work is planned to eventually include all Forests of the Region where commercial forest stands are threatened with destructive insect attack. For the present this work will be confined to the ponderosa pine forests east of the Cascades where the western pine beetle is an insect of outstanding seriousness. If time permits, it is hoped to eventually include most of the ranger districts containing commercial ponderosa pine stands of any importance in the sample plot program primarily because of its training value and its help in estimating beetle losses.

C. Personnel

Barkbeetle survey work of this character requires the services of a three-man crew, both for the establishment and for the annual remeasurement of the sample plots. Ordinarily, such a crew will consist of one trained entomologist and two Forest officers assigned to the work by the local Forest Supervisor. It is preferable that one of these Forest officers include the ranger in whose district the sample plot is located.

D. Location of the plot

In the ponderosa pine belt, plots for the study of western pine beetle outbreaks should be located in the heart of natural basins or units of this species. The plot should be typical of the virgin ponderosa pine stands of the local district, midway between the lower levels of the fringe type and the higher levels of the mixed pine and fir type. The site should represent average Site IV, if possible.

A plot should be selected on which the cover is as uniform as possible and not cut up by broken topography, deep canyons, open spaces, burns or other unusual features.

E. Size of the plots

Plots should not be less than 160 acres in area, and preferably should cover a half or a full section. Once a plot is established, a half section makes a convenient unit easily cruised by a three-man crew in one day.

F. Setting up the plot

After the location of the plot has been decided upon, the boundaries should be marked or designated so as to be recognizable by subsequent field parties.

On areas which have been previously surveyed and sectionized, the best plan is to re-run and reblaze these land lines and use them as a base for the survey. However, if the lines are sufficiently well marked, they may be used without rerunning. Where no land lines are available, a base line should be established, the line trees blazed and markers set at ten chain intervals. These are later used as starting points for strips which are run at right angles to the base line.

G. Cruising the plot for stand data

After the location and boundaries have been definitely established, the plot should be cruised and mapped to obtain all necessary information as to its physical and silvicultural characteristics. In this cruise the following data should be obtained;

1. A map of the area on an eight inch to the mile scale showing:

(a) Important topographic features, ridges, streams, roads, etc.

(b) Cover type differences such as location and size of openings, cuttings, burns, changes in type or site conditions, etc.

(c) Notes as to altitude, general slope and exposure, character of soil, etc.

2. A 10 per cent timber stand cruise or inventory of the living merchantable timber above 10 inches d.b.h. by Dunning's tree classes.

3. Height measurements on about three trees of each diameter, - or enough trees as a basis for a satisfactory height curve.

4. Increment cores from approximately ten trees of Dunning's Class 1,-trees from 75 to 150 years of age.

For the purpose of securing the above stand data, the duties of the three men in the party are as follows:

Compassman

Runs the compass and drags a 200-foot steel tape attached to his belt.

Makes the map of the area (on 8" to the mile scale) showing topographic and cover type features.

Takes notes on general physical features, altitude, exposures, dimensions of plot, location and marking of section corners, etc.

Cruiser

Carries calipers and takes diameter of all trees in a chain strip (33 feet on either side of the compass line).

Carries increment borer and secures ten or more cores from Class 1 trees.

Note Keeper

Holds rear end of chain and checks with compassman on distances.

Classifies trees measured by cruiser as to Dunning's tree class and tabulates them by species, diameter and tree class.

Carries an Abney level and takes the heights along center line of trees 200 feet distant. Secures a random sample of heights of about three trees for each diameter. Plots these on a cross-section graph and takes more if necessary to give a reasonably smooth height curve.

H. Surveying

H. Surveying the plot for loss data

Once the plot has been established, the annual inventory of loss is a relatively simple matter and a three-man crew can easily cover the average plot of 320 acres in a day's time. Even in the case of new men, the initial inventory of the loss data can usually be done in two days.

One man acts as compassman and, by use of a staff compass and pacing, runs lines at intervals of ten chains back and forth through the plot. Two spotters work on either side of the compassman and cover one hundred per cent of the area in their tally of all dead or dying trees.

The data secured includes a map showing the location of each dead tree; a record giving the serial number of each tree, its species, cause of its death, its diameter and tree class.

The dead trees are blazed on the north side, numbered serially with black timber crayon, and designated as to year and season of death. An example of the symbols for this purpose is as follows:

$\frac{31S}{137}$ is a tree killed in the summer of 1931 with a serial number of 137;

$\frac{32W}{162}$ is tree #162 which died in the winter of 1932; etc.

The duties of each man in the crew when data on insect losses are secured, are as follows:

Compassman

Runs staff compass and paces.

Makes a map showing location of each tree or group of dead trees and the respective serial numbers as called out by the spotters.

Each Spotter

Examines all dead or dying trees not previously marked. Blazes each dead tree on the N side and marks with symbol showing year and season of death and serial number.

Records serial number, species of tree, cause of death, year of death, diameter and tree class.

During the first and initial survey, all snags should be blazed, marked with an SN and tabulated as to diameter. The marking of all snags will prevent confusion when subsequent annual tallies of dead trees are made. After the completion of the survey of each plot, the current losses should be summarized by years, cause of death and season (summer or winter). A copy of these summarized totals should be kept by the ranger in his files. The original records should be sent to the Regional office for further analysis.

I. Classification of Dead Trees According to Year and Season of Loss

Season of Loss

In order to compare the intensity of beetle attack from one season to the next, the year or season of a tree's death is considered as coincident with the time of fatal attack, even though the tree's foliage may not fade until many months later. For instance, trees heavily attacked in the fall of 1932 which do not fade until the following May are classified, not as 1933 killed trees, but as 1932 winter brood trees. Trees that appear to be unsuccessfully attacked by the beetles are not included in the tabulations until a fatal attack does occur.

The following description of the characteristics of insect-killed trees will be of assistance in classifying the trees according to year and season of attack. These descriptions will also be of value to all Forest officers engaged in pine beetle detection and control work.

Characteristics of Ponderosa Pines Killed by Western Pine Beetle

Explanatory note: - In the table to follow, the most recently insect-killed trees are given first. The insect-killed trees are listed in the chronological order of their attack by the western pine beetle, beginning with those most recently killed and ending with those that have been dead the longest. For the purpose of clarity, the time of attack has been entered for all portions of Section I, "Fall Cruising", to make it applicable for cruising in the fall of 1933.

I. Fall cruising (September, October and November, 1933).

1. Attacks of current year, 1933.

A. Winter brood (attacked in late summer or early fall, 1933).

a. Foliage - Fresh green, fading green or straw yellow.

b. Bark - Moist and fairly tight. In late fall sometimes loose. Only red dust in bark crevices. Pitch tubes soft and red. Insect holes - few, small and round. No large oval holes. Usually no woodpecker work, except fresh large patches. No fungus fruiting bodies.

c. Wood - Moist, clear or slightly blue-stained. No worm holes.

d. Insects found - New attacks, parent adults, eggs or larvae of western pine beetle. Round-headed borers small to half grown larvae. Clerid adults on bark and small clerid larvae in or under bark.

B. Summer brood (attacked in early summer, 1933).

a. Foliage - Yellow or red. No loss of needles. New growth of shoots short.

b. Bark - Moist and usually loose. Red or white dust or both, in crevices. Pitch tubes hard and red. Many small, round insect holes in bark - no large, oval holes. Little or no woodpecker work except small, round excavations. A few soft, fresh fungus fruiting bodies are likely to be present.

c. Wood - Moist and blue-stained. The beginnings of a few worm-holes.

d. Insects found - All or nearly all of western pine beetles have emerged but some larvae, pupae and new adults can sometimes be found at the base and north side of trees. No clerids are likely to be found running around on surface of bark, but full grown larvae or pupae may occur in outer bark. Round-headed borers appear as full-grown larvae.

2. Attacks of previous year, 1932.

A. Winter brood (attacked in late summer or early fall, 1932).

a. Foliage - Red. Most of needles still on trees. Since attack not made until late in growing season, the new growth of shoots and needles is complete.

b. Bark - Usually dry and loose. White dust in crevices. Pitch tubes hard and yellow. Many small, round insect holes in bark - some large, oval ones. Woodpecker work in large patches appears to be somewhat weather-beaten. Fungus fruiting bodies few in number, small, dry and hard.

c. Wood - Dry or moist. Badly blue-stained. Worm-holes few to many.

d. Insects found - No western pine beetles in any stage. Round-headed borers few to many, but their large exit holes are conspicuous. No clerids.

B. Summer brood (attacked in early summer, 1932).

a. Foliage - Dark red. Many of normal needles have fallen but short needles still present on tree.

b. Bark - Usually dry and loose and full of loose boring dust. Old white and red dust packed in outer crevices. Pitch tubes hard and yellow. Many small, round insect holes. Some large oval holes. No recent woodpecker work. Old woodpecker work badly weather-beaten. Usually many large, hard, dry fruiting bodies, some of which have broken open or have fallen.

c. Wood - Dry or moist, stained, some punkiness. Usually many worm-holes.

d. Insects found - Only a few secondary insects.

3. All attacks prior to previous year (attacked prior to 1932).

a. Foliage - Dark red-brown or black. Most of needles have fallen.

b. Bark - Usually dry and loose - some of it has probably fallen off. Sawdust in outside crevices not conspicuous. Pitch tubes hard and yellow. Insect holes abundant and of various sizes and shapes. Woodpecker work badly weather-beaten. Fungus fruiting bodies hard, dry, broken or fallen.

c. Wood - Dry or moist. Hard or punky. Badly stained - often completely riddled by worm-holes.

d. Insects - Only secondary insects and spiders.

II. Summer cruising (June, July and August).

1. Current year.
   A. Winter brood. Will not appear and develop until fall.
   B. Summer brood.
      a. Foliage - Fresh green, fading or straw yellow. All needles present.
      b. Bark and wood - Fresh and moist under bark. Wood only slightly blue-stained. Very little woodpecker work. Pine beetles present as adults, eggs, larvae or pupae. Secondary insects plentiful.

2. Previous year.
   A. Winter brood.
      a. Foliage - Sorrel to red. All needles present.
      b. Bark and wood - Fresh and moist under bark. Bark loose from tree. Wood hard, never punky. Woodpecker work often abundant. No puff ball fungi. Secondary insects abundant. Round-head larvae full grown.
   B. Summer brood.
      a. Foliage - Dark red, never black. Remaining needles on tree abundant to moderately sparse.
      b. Bark and wood - Bark dry, rarely moist. Loose from trunk and filled with boring dust of large round-heads. Wood dry and hard on south side and often punky on north side. No woodpecker work. Fresh puff-ball fungi present. Few secondary insects.

3. Older loss - all attacks.
   a. Foliage - Dark red to black. Most of foliage fallen.
   b. Bark and wood - Bark very loose, some of it has fallen from trees. Puff-ball fungi broken open. No secondary insects. A few spiders and pseudo-scorpions under bark.